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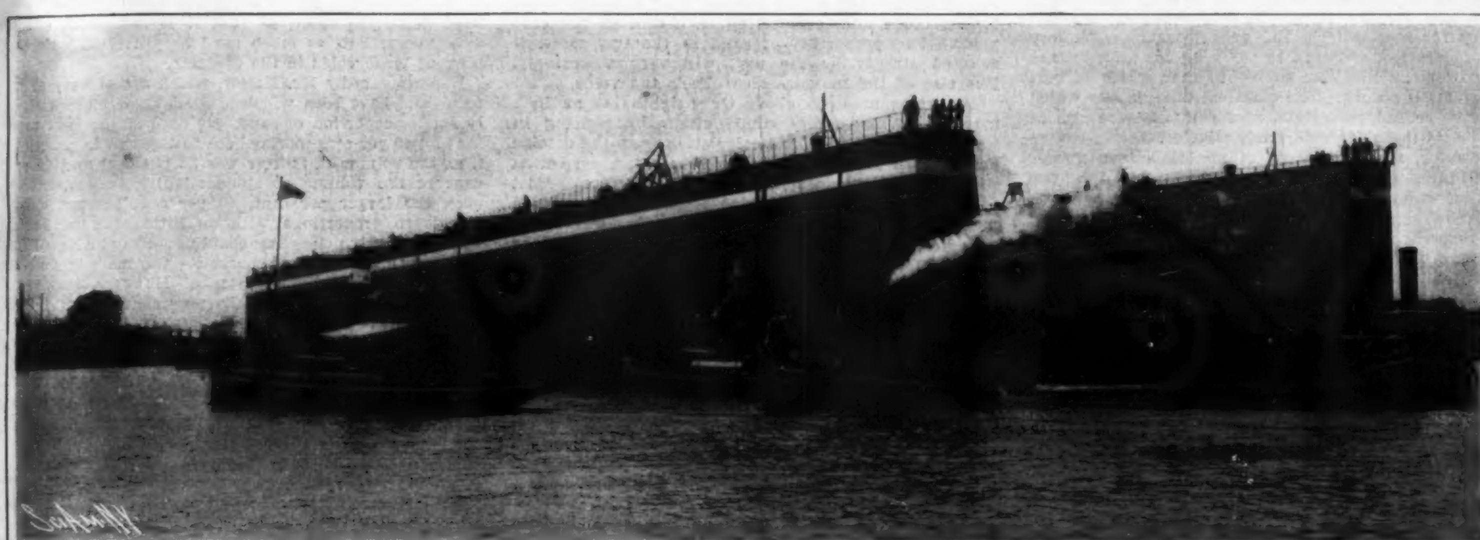
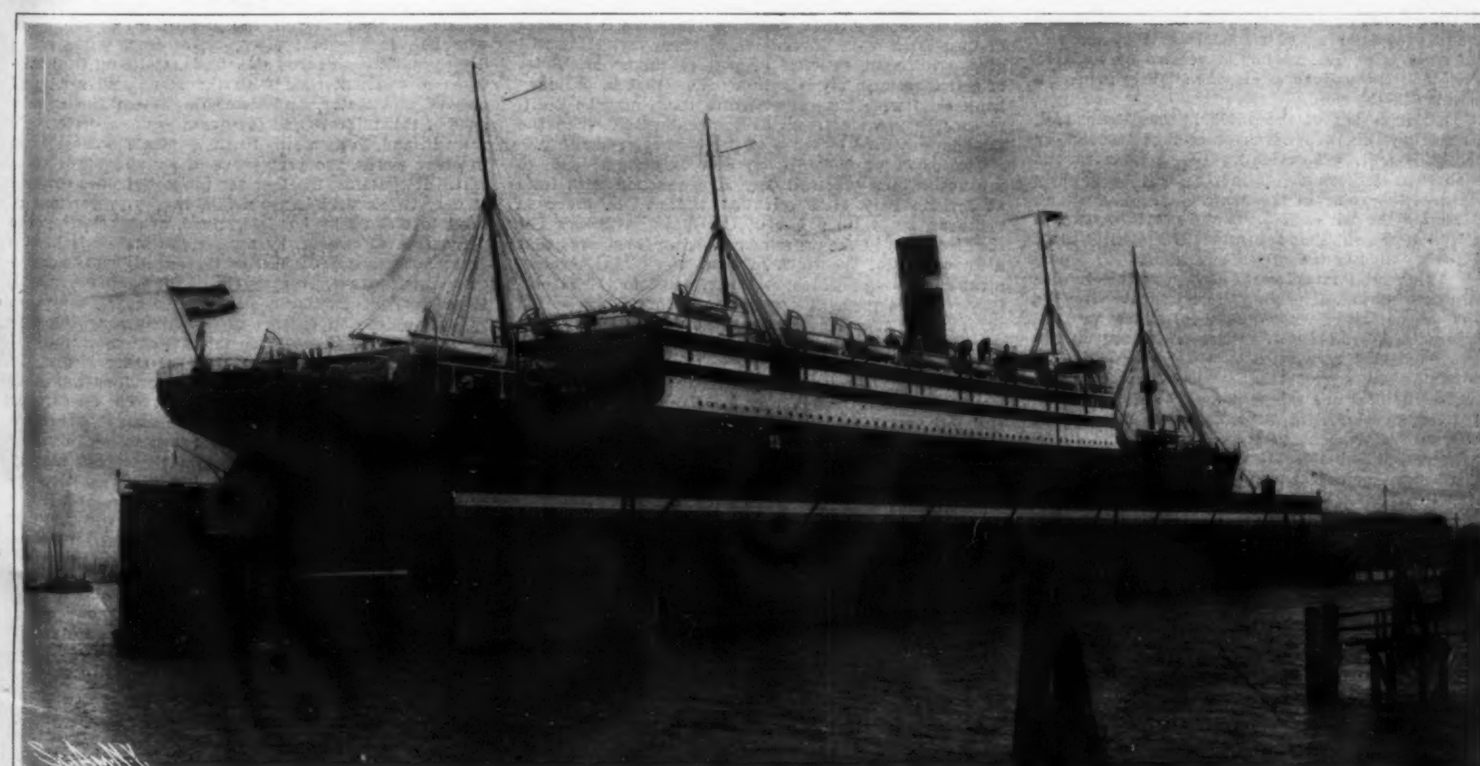
THE NEW ROTTERDAM ELECTRICALLY-OPERATED FLOATING DOCK.*

By Frank C. Perkins.



TOWING THE DOCK TO ITS MAASHAVEN BERTH.



THE NEW ROTTERDAM FLOATING DOCK WITH THE LINER "NEW AMSTERDAM."

THE NEW ROTTERDAM ELECTRICALLY-OPERATED FLOATING DOCK.

One of the most interesting of modern floating docks has recently been constructed for Rotterdam, Holland, having a lifting capacity of 15,600 tons. One of our illustrations was taken when the dock was towed by several tugs at the head and at the stern to its permanent berth in the Maashaven, while the other was taken with the "New Amsterdam," a twin-screw steamer of 17,000 tons, belonging to the Holland-American Line, in the dock.

This most interesting floating dock of modern construction is of extremely large size, and belongs to the town of Rotterdam. It has side walls on both sides, and seven pontoons, the latter with gaps of 20 feet between them.

This floating dock has a total length of 558 feet, with a width of 118 feet, and an average pontoon depth of 11.4 feet. The decks and bottom of the pontoons have a slight inclination, and the side walls are 36.68 feet high, with a width of 15.74 feet at the bottom and 11.4 feet at the top.

It may be stated that each of the pontoons has three longitudinal bulkheads, of which one is at the center, and by which each pontoon is divided into four compartments of almost equal capacity.

In order to pump out the water in raising this floating dock, each half of the pontoon is provided with a horizontal centrifugal pump, fixed at the lowest possible level under the side walls and close to the bottom of the pontoon. These pumps have vertical spindles, and are driven by direct-coupled electric motors, located on a gallery and running from end to end of each side wall, at a height of about 19.68 feet from the deck level.

It is also interesting to note that all of the other machinery, including the tackle and gear, as well as the leakage pumps and capstans, is also operated by electricity. The electric current required for driving the motors on the dock is supplied from a storage battery and electrical insulation, about half an hour's distance from the dock.

It is also of interest to note that all of the pumps and valves are worked from a single point, this being particularly interesting and important. The water level in every compartment is clearly visible by pneumatic indicators, and every form of labor-saving device and modern convenience has been installed that

* Specially prepared for the Scientific American Supplement.

is possible. The dock is electrically lighted, and may be operated day or night without difficulty, and the electric power has given most excellent satisfaction for this class of service.

PROPORTIONING CONCRETE.*

As the uses of concrete increase, the necessity grows for a greater economy in construction. To reduce the cost of materials one naturally considers the use of leaner proportions. To decrease the proportion of cement without corresponding loss in strength, the aggregate must be specially graded or such materials selected as will increase the density of the set concrete.†

Just how far it is economical to go in increasing the density depends upon the conditions. If, as might be possible on a small job, the cost of materials is reduced 10 cents per cubic yard by substituting a leaner but denser mixture, and, at the same time, if the cost of labor of preparation is increased by 15 cents per cubic yard, it is obviously poor economy. It may, in fact, sometimes cost more in time and trouble and materials to make a lean concrete of high strength than to attain the desired result by using more cement and the materials nearest at hand.

On the other hand, if a large mass of concrete is being laid per day, it may be good economy to spend money for special tests and provide extra machinery for preparation, and even to pay a higher price for the sand or stone in order to secure that which is best suited for the work. The question, then, is one which must be settled by estimates of cost, and the size of the job is the chief determining factor.

However, special grading of materials is a matter which interests us much less frequently than the practical selection of proportions for structures where the choice of aggregates is limited and the character of the concrete such that the problem is simply one of selecting the best relative proportions of the available coarse and fine aggregate, or, perhaps, comparing two materials which may be obtained at trifling difference in cost. Therefore, before considering the effect of different characters of aggregate, we should first study the experimental methods for proportioning two materials and for simple comparisons of quality.

In experimental determination for selecting proportions it is a generally accepted fact that for maximum strength we should aim at a mixture having the smallest percentage of voids, but it is by no means settled as to *how* this result shall be obtained, even experimentally. For convenience in studying the question we may classify the various plans which are followed:

(1) Arbitrary selection; one arbitrary rule being to use half as much sand as stone, as 1:2:4 or 1:3:6; another, to use a volume of stone equivalent to the cement plus twice the volume of the sand, such as 1:2:5 or 1:3:7.

(2) Determination of voids in the stone and in the sand, and proportioning of materials so that the volume of sand is equivalent to the volume of voids in the stone and the volume of cement slightly in excess of the voids in the sand.

(3) Determination of the voids in the stone, and, after selecting the proportions of cement to sand by test or judgment, proportioning the mortar to the stone so that the volume of mortar will be slightly in excess of the voids in the stone.

(4) Mixing the sand and stone and providing such a proportion of cement that the paste will slightly more than fill the voids in the mixed aggregate.

(5) Making trial mixtures of dry materials in different proportions to determine the mixture giving the smallest percentage of voids, and then adding an arbitrary percentage of cement, or else one based on the voids in the mixed aggregate.

(6) Mixing the aggregate and cement according to a given mechanical analysis curve.

(7) Making volumetric tests or trial mixtures of concrete with a given percentage of cement and different aggregates, and selecting the mixture producing the smallest volume of concrete, then varying the proportions thus found by inspection of the concrete in the field.

Still further variety in methods is produced by different handling of the stone and the sand, some engineers measuring the voids in the stone loose, while others compact the stone to a greater or less degree. Other complications are introduced by the different methods of determining voids, whether by pouring water into the stone or sand, pouring the stone or sand into water or weighing and calculating the voids from the specific gravity.

After the proportions have been selected, the questions arise as to whether we shall frame the specifications to require loose or packed measurement of the aggregate, loose or packed or arbitrary measurement of the cement, or weight measurement of all the materials; or shall the specifications state that the concrete shall contain a certain quantity of cement in a cubic yard of concrete? Shall we adopt two aggregates, merely sand and stone, or shall we mix two grades of sand and two grades of stone? These are some of the problems which confront the man who would proportion his concrete for maximum economy.

At the outset we must admit that the nature of the materials used in concrete, the daily and even hourly variation in the quality, sizes and percentage of moisture, prohibit absolute accuracy either in fixing proportions or in practical measurement of materials. Yet different methods of testing for the purpose of fixing proportions in advance may produce, with the same materials, as great variation as between 1:2:4 and 1:3:7½. Surely such possible variations are not to be ignored. Differences in the methods of measuring proportions by the contractor may produce nearly as great variation.

It may be well to review first the causes of the variations in tests for proportions, the sources of errors and the part which good sense and careful judgment must play in the matter. Suppose we consider what may be termed the ordinary method, which is most commonly given in print and employed quite widely in practice—the method of first determining, separately, the voids in the stone and the voids in the sand, and then proportioning the volume of the sand equivalent to the voids in the stone and the volume of cement slightly in excess of the voids in the sand. The chief variation in the stone, if it does not contain sand or dust, is due to the degree of compacting. Some adopt loose measurement and others packed, while many use slightly shaken measurement. One man may measure broken stone *loose* and find 50 per cent voids, while another may take the same broken stone and, compacting it, obtain 40 per cent voids. The proportion of sand in the two cases, if selected strictly by the test, will vary accordingly. The size of the measure also affects the voids.

The voids in stone above three-eighths of an inch may be correctly determined either by pouring in water, or by weighing and calculating from the specific gravity. In either case, if a porous stone, correction should be made for water absorbed in the pores. Most rock in this vicinity is so dense that this absorption may be neglected. If the stone contains dust, even a small proportion, the air is held in the pores and inaccurate results are reached. Accordingly, for fine material, it is more accurate, in fact necessary, to adopt the weight and specific-gravity method. This is also the simplest method with sand, as the specific gravity of sand averages about 2.65. In the vicinity of Boston I have found it slightly higher than this, ranging near 2.7, probably owing to the pieces of trap and other heavy rock contained in it. Either figure is sufficiently accurate to use for void determinations, provided one desires to test the voids. The moisture in the sand must be corrected for by drying a sample and determining the percentage of moisture.

It is thus comparatively easy to find the voids, both water and air voids, in a certain sample of sand, but when we come to figure from these voids the proportion of cement to select, we meet with a greater difficulty than in the relation of the stone to the sand. How shall we select the sample of sand? Shall it be dry or moist, loose or shaken, measured in a small measure or in a large one? Every one of these variations will give a different ratio of cement to sand. Examples of actual tests in my laboratory show that in ordinary bank sand with natural moisture there may be a difference as great as from 53 per cent voids, when the sand is measured loose, to 42 per cent after shaking.

The effect of moisture on Cow Bay sand came to my notice in a practical way in connection with tests at Jerome Park Reservoir last winter. In order to make an entry upon one of the tables, although not for direct use in the experiments, as we considered that a knowledge of the voids in sand was of little value, a sample of sand which had been dried in the laboratory was weighed. Its weight was found to be 103 pounds per cubic foot, corresponding to 38 per cent voids. The same sand was then placed out of doors during a rain, and after lying in the sun for two days following was retested and found to weigh 83 pounds per cubic foot, corresponding to 52 per cent voids. By the theoretical method of proportioning, in one case the proper mortar would be about 1:3 and in the other case about 1:2, and yet the sand was the same and, therefore, the 1:3 mortar would have been only about two-thirds as strong as the 1:2.

I made the statement a few minutes ago that different methods of testing might result, with the same materials, in proportions as widely different as 1:2:4 and 1:3:7½. The case cited shows this difference in the mortar. The difference in the ratio of sand to stone (i. e., 2:4 in one case and 3:7½ in the other) may be reached on the one hand by measuring the stone loose and finding 50 per cent voids, and on the other by compacting it before measuring the voids and finding 40 per cent voids.

Perhaps I have dwelt too long upon the inaccuracies of proportioning, but it seems to me that this is a matter of the greatest importance to us in order that we may avoid such inaccuracies, or at least, exercise very careful judgment in drawing conclusions from them. For example, in the case just mentioned, which is correct, the 1:2:4 or the 1:3:7½? In other words, shall we measure the stone loose or compacted, and shall we measure the sand dry or moist? Or shall we throw aside this method of determining proportions and select some other? As I shall suggest presently, personally I do not place much dependence upon the determination of voids in the different dry materials because of the variations I have mentioned. However, some information may be gained from such tests, if the character of the materials is taken into consideration and the methods made to apply to them. For certain materials, for example, the stone may be compacted before measuring the voids and the proportion of sand thus formed, measured loose, will be sufficient to fill the voids when making the concrete. This is the case when the stone is coarse and of fairly uniform size, such as 1½-inch macadam stone, and contains no small stone. The voids are then large, and particles of ordinary sand will fit into them. On the other hand, if the stone is crusher-run, even with the dust screened out, and the sand contains a large proportion of coarse grains, many of these grains will be too large to fit into the smaller voids of the stone, and therefore will increase the bulk. Consequently, a larger quantity of the smaller grains must be had, and to do this the total quantity of sand must be more than enough to fill the voids in the compacted stone. This question of the relative sizes of grains, which I think was first brought to notice by Mr. William B. Fuller, is frequently neglected in fixing proportions.

This principle is well illustrated in the use of gravel and sand screened from it and remixed. Ordinarily screened gravel, measured loose, has about 40 per cent voids, so that one would naturally expect a mixture of, say, 1:2:5 to work satisfactorily. If the gravel is compacted so that its voids are 32 per cent, the theoretical mixture would be 1:2:6. However, in practice, the grains of the gravel and sand overlap each other; that is, the smallest grains of gravel are smaller than the coarsest grains of sand, and the voids in the gravel are consequently too small for the large sand grains to enter, so that it is sometimes necessary to use half as much sand as gravel in order to prevent large voids in the concrete.

Experiments by Mr. Rafter, which are of very great value and have been widely quoted, show a surprisingly small proportion of sand. He used 35 per cent mortar and 40 per cent mortar both in test and in practice; i. e., the volume of mortar was 35 per cent and 40 per cent of the volume of stone slightly shaken. Now, even the larger per cent, 40 per cent mortar, corresponds to proportions with as little sand as 1:2:6, which probably none of us could use with our New England sand and make good concrete. Our materials would require a 1:2:5 or 1:2½:5 mix. However, if we examine the analysis of Mr. Rafter's sand, we find that 92 per cent of it passed a No. 30 sieve (30 meshes per linear inch). The grains were thus small enough to enter the voids of the stone without appreciably increasing the bulk; in fact, in many of Mr. Rafter's tests the volume of the concrete was considerably less than the broken stone slightly shaken. His sand, although apparently so fine, was not of bad quality for concrete work, because there was very little dust in it, and therefore the cement entered the sand voids.

We are coming now to one of the principal points which I wish to make in considering this subject of proportioning. The cases cited show that the experimental void determinations cannot be expected to give practical results, but various allowances must be made. Now, why not, instead of making tests one way or another, guessing at the best way to handle the materials and then altering the proportions by judgment, why not, in the first place, or, at least, after rough determinations to serve as a basis, make up trial mixtures of the materials with the stone and sand and cement and water, and determine, from the appearance of this mixture and the quantity of concrete made from it, and, to go a step further, from the density, or, in other words, the percentage of air and water voids which it contains, whether the proportions are correct? If only two materials are available, the proportions of sand to stone may be determined, after selecting the percentage of cement, by mixing the materials in several proportions and selecting the one giving the smallest volume with a given weight of aggregate (corrected, if necessary, for difference in specific gravities); also, judging by the appearance of the mixture, taking care on the one hand that there is sufficient mortar to fill the voids in the stone—that is, that there is a slight excess on top when lightly rammed—and, on the other hand, that this excess is not too great. The appearance of the concrete also should not be coarse, but there should be enough cement and fine particles of sand or dust to fill the pores and make a fairly smooth mortar.

In the field this method of inspection is also applicable. In laying the reservoir bottom at Jerome Park, New York city, for example, there was more or less variation in the broken stone and screenings from day to day, and the inspectors were given authority to slightly vary the relative proportions of these two materials, always keeping the proportion of cement to total aggregate at 1:7, so as to give a mix which worked just right in place.

I will not go farther into the methods of making these tests, because I do not wish to take too much of your time, but shall be very glad to answer questions in regard to them. Materials cannot be satisfactorily mixed dry by trial with ordinary apparatus and thus proportioned, because there is so great separation of the coarse and fine particles. Then, too, the addition of the water changes the relations, since a fine sand requires more water to produce the same consistency than a coarse sand, and consequently makes a larger bulk of mortar. Therefore, for the trial mixtures all of the ingredients must be used, including the cement and the water, as well as the aggregates.

The methods are very useful not only for determining the proportions of two materials, but for comparing the value of different aggregates, and also selecting proportions where the aggregate is separated into three or more parts. I have just completed a series of tests for a client in which we found that by changing and grading the sizes of the particles, we could obtain a strength two and a half times as great with the same proportions of cement, while, on the other hand, we could maintain equal strength with 40 per cent less

* A paper by Mr. Sanford E. Thompson, M.B.S.C.E., read before that society and published in the Journal of the Association of Engineering Societies.

† The term "density" I use in its now generally accepted meaning, as the ratio of solid particles in a unit volume of concrete. It is thus the complement of the voids. For example, if a piece of concrete has 15 per cent voids (including the air and the water), 85 per cent of its volume must be solid material, and its density is 0.85.

cement. In connection with such combinations, the use of mechanical analysis diagrams and curves very greatly facilitates matters, and in many cases the correct proportions can be directly predicated in advance if the mechanical analysis curves for the different materials are plotted from the sieve tests and combined. Mechanical analysis methods are eminently scientific and should be destined to greatly increased use both alone and as an auxiliary to other methods of testing.

From these somewhat general observations and from the results of tests which cannot be presented this evening, we may offer the following suggestions as guides to proportioning:

(1) The size of the largest stone in the aggregate should be as great as is consistent with proper placing of the concrete.

(2) If size of stone is small, a richer mixture must be used: thus 1:3:6 is a fairly rich mix with 2-inch stone, but a lean mix with ½-inch stone.

(3) If sand is fine, a smaller quantity may be used in proportion to the stone.

(4) For concrete, a sand with too large a percentage of very coarse grains may be detrimental, because they will not fit into the voids of the coarse aggregate.

(5) If the broken stone or gravel contains fine stuff, a smaller proportion of sand must be used.

(6) Better proportions are obtained in practice by screening the sand or dust from the coarse material and remixing in required proportions, than by using the run of the bank or the run of the crusher.

(7) If the mortar in concrete is rich, say, up to 1:2½, sand should be coarse, with comparatively few fine grains. A lean motar, on the other hand, is improved not only in strength, but in smoothness of working, by using a sand containing dirt or dust.

(8) If fine sand must be used, the proportions must be richer than for coarse sand, because a fine sand makes a mortar of lower density.

A very important point still in question is with reference to the use of fine sand for water-tight work. A few permeability tests which I have made recently indicate that a slight excess of fine grains in the sand is often beneficial for concrete designed for water-tight work. For example, I greatly increased the water-tightness of a 1:3:6 concrete made with ordinary coarse bank sand of a quality to produce a strong mortar by substituting for one-sixth part of the sand an equal weight of very fine bank sand. This fine sand decreased both density and strength and yet increased the water-tightness. A further increase in fine sand did not appreciably affect the water-tightness at an early age, but on longer time tests the specimen with the small addition of fine sand was much superior to those with a larger quantity of fine grains. In a 1:2:4 concrete made with coarse bank sand, an addition of fine sand did not improve it, evidently because there was a sufficient excess of cement to render more fine sand unnecessary.

IMPROVING ROADS BY OILING AND BY CALCIUM CHLORIDE TREATMENT.

The improvement of country roads, says the Engineering Record, has carried with it the necessity of finding some practicable means, if it is possible to do so, of making them as nearly as possible, dustless. That end fully attained is probably far too much to anticipate, although it is reasonable to expect that the dust nuisance may soon be abated by proper treatment and maintenance of the road surface. It has been found, fortunately for the country at large, that nearly every locality has road materials more or less suitable for the construction of a high grade of road, although there are decided differences of excellence among these grades. Some crushed stone is much better than others, and some gravel road material will give better results than others, but as a whole it may safely be said that under suitable inspection every locality will afford satisfactory material for the improvement of its roads.

In every case, however, where sprinkling is not carefully and continuously resorted to, it requires but a few days' wear in dry weather to grind almost any road surface into so fine a powder that it is easily carried about by the wind, resulting not only in carrying away the road material, but creating an insufferable dust nuisance in connection with that operation. The problem is to find some feasible and agreeable method of avoiding these results in the absence of continuous sprinkling. The application of oil and tar have both been tried with varying success, depending upon the method or the conditions of application. In many portions of the country where the layman has heard that the application of crude petroleum is a good preventive of dust, that material has been sprinkled freely upon the ordinary surface of the road. The dust and loose particles less finely divided of course receive the oil and absorb it. The result is all too frequently a mealy mixture of dirt and crude petroleum of disagreeable odor and of such consistency that it is readily thrown into vehicles by the wheels, damaging the clothing of the occupants and the fittings of the vehicle itself. The conclusion is at once reached that the oil treatment is decidedly worse than nothing, especially as the result after a period of dry weather is no less dust than before and certainly of a not less disagreeable character. Almost the same observation can be applied to the application of tar in the same ignorant and inefficient manner.

In a recent issue of The Engineering Record there was published the results of certain tests of tar on macadam roads at Jackson, Tenn., and there have been many places throughout the country where both tar and crude petroleum have been applied to road surfaces with the most efficient and satisfactory results. Effective methods of application of these materials require but little if any more care than ineffective methods and probably are little or no more costly. If town officials or country residents are minded to use crude petroleum or tar for the preservation of their road surfaces or for the abatement of the dust nuisance they should at least take sufficient pains to inform themselves carefully as to the proper methods of application involving the prior methods of treatment of the road surfaces. The dust and other loose material should be carefully cleaned from the entire road surface to be treated. This cleaning should be done in such manner as to be equivalent to a thorough scraping and sweeping, leaving absolutely uncovered the hard road surface beneath the ordinary dust layer. Furthermore, this hard cleaned surface should be absolutely dry, as unsatisfactory results are definitely certain to follow any application of either material to a wet or even damp roadway. If tar is used it must be heated to a proper temperature so as to be applied in the proper consistency. If the crude petroleum or tar is then sprinkled or applied properly to the exposed surface it will be absorbed by the latter, for which absorption ample time should be afforded. The action of the tar seems to some extent at least to produce a cemented mass, or covering, so to speak, as a part of the hard roadbed. After a sufficient time has elapsed to allow the oil or tar to be thoroughly absorbed by the material which receives it, traffic may be resumed and it will then be found that while the roads may not remain absolutely dustless for a long period of time, they will resist most effectively the raising of any sensible amount of finely divided material for a considerable period.

Enough experience has already been had in reference to these results to indicate that they may be satisfactorily reached under intelligent treatment on any improved road. Indeed, they constitute means or methods of maintenance that may well be resorted to in any locality where the best road conditions are desired to be attained, but it must be remembered that the application of either oil or tar must be conducted, like any other good road engineering work, with intelligence and scrupulously in accordance with those conditions which experience has shown to be absolutely essential for success.

Much attention is now being devoted to the general subject of road improvement. Among other features that have received careful thought is the desirability of finding an inexpensive means of keeping down the dust on much-traveled public highways, park roads, etc., other than by the use of water. Roads sprinkled with water require such treatment daily and oftener in dry, hot weather, to keep them in good condition.

The use of oil on such roads was a marked step in advance; but this has certain disadvantages, among others the cost of application, the offensive odor, and the fact that it injures the rubber tires of vehicles, etc., and has an injurious effect upon horses' hoofs.

The use of calcium chloride remedies these difficulties in an efficient and comparatively inexpensive manner. A road sprinkled with calcium chloride will, for a long period, remain damp and hence dustless; because, having a strong affinity for moisture, calcium chloride absorbs, during the hours of evening and night, whatever moisture it may have lost during the day.

The suggestion for its use came from Brunner, Mond & Co., of Northwich, Cheshire, England, who operate the Solvay process there and who induced the surveyor or engineer on the Northwich Urban District Council to make a series of carefully-conducted experiments.

These proving highly successful, the following report was made:

The effect as a dust-layer is satisfactory. It has been my opinion for a long time that a cheap material which would allow of frequent application was the only one that would be acceptable to public authorities, considering the present construction of macadamized roadways.

The liquor has the characteristic of absorbing the moisture from the atmosphere, and consequently the evaporation, which is a feature in the use of water, is eliminated, with the result that each night the road surface regains the amount of moisture, thus prolonging the effect of the treatment.

It has also a decided advantage over water when considering the cost of maintaining and cleansing of the roads, to say nothing of the advantage which might be claimed from a public health point of view.

The advantages in the use of this solution for race tracks, parade grounds, railroad and shop yards and other places where dust rises freely, must at once be apparent.

A 20 per cent solution (1.200 specific gravity) is made by using 3 pounds of "Solvay" 75 per cent calcium chloride per gallon of solution required; or a heavier solution of, say, 40 per cent could be made and used more sparingly, this, in course of time, becoming diluted to 20 per cent. Calcium chloride can be had for this purpose in several forms, among others, in the three here named:

1. The 75 per cent solid in 635-pound iron drums, which is stored at over 50 points in the United States and Canada.

2. The 75 per cent granular in 325-pound wooden barrels, which can be had at about 30 storage points.

3. The 40 per cent solution, in 4,500-gallon tank cars, furnished by the shippers without charge and returned free when empty by the railroad companies, and in 110-gallon iron drums, which are returnable for credit when empty.

The 75 per cent solid is the cheapest form; the 75 per cent granular costs a little more, but does not require to be broken up and dissolves more readily; while the 40 per cent solution is the most convenient for use and, at all points to which the freight rates are not high, is reasonably cheap and on the whole the best especially where large quantities are needed.

Calcium chloride solution is applied with any ordinary watering cart.

A road to which calcium chloride has not previously been applied should be sprinkled thoroughly twice over with this solution, an interval of one day elapsing between the first and second treatment.

For the first treatment, a length of 100 yards of road 8 yards wide, that is 800 square yards, will require about 800 gallons of solution, about 500 gallons for the first and 300 gallons for the second sprinkling on the next day. For subsequent treatments, one thorough sprinkling will suffice each time, using about 300 gallons of the above solution per 800 square yards; this will probably have to be repeated during the ordinary sprinkling season about four times on an average; it is impossible, of course, to give a definite figure, because much depends upon the dryness or otherwise of the season, the quality of the road and the amount and character of the traffic.

M. LIPPMANN'S METHOD OF PHOTOGRAPHY IN COLOR.

The original method of photography in color proposed by M. G. Lippmann was based on the production of interference fringes in the photographic plate, and had the disadvantages of requiring very delicate adjustments and a long exposure. In the Comptes Rendus for July 30 M. Lippmann gives an account of a method in which long exposures are not required. Consider a photographic spectroscope consisting of a slit, a prism, a lens, and a sensitized plate. The light falling on the slit is analyzed by the prism, and the rays produce a corresponding number of dark lines on the negative, each of which is a conjugate image of the slit. If a positive is taken from this negative, and the former placed in the exact position originally occupied by the latter, the system is reversible. If the plate is now illuminated by white light, the light passing through the transparent portion of the plate formed by any particular line will produce at the slit only that ray which originally imprinted the negative. On the whole spectrum, the net result will be to reconstitute at the slit the original color. In order to apply this principle to photography in colors, the following apparatus has been arranged. The single slit of the spectroscope is replaced by a series of slits very close together, consisting of fine transparent lines ruled five to the millimeter. This grating is fixed at one end of a solidly built box, the other end carrying the photographic plate, and between these is a converging lens, in front of which is a prism of very small angle. The object to be reproduced is projected on the grating, illuminated with white light. The light passing through the prism and lens falls on the sensitive plate, producing a negative in black and white, which under the lens appears lined, each line being divided into small zones, which are parts of an elementary spectrum. If the negative be now replaced in its original position and illuminated by white light, the eye being placed at the distance of distinct vision from the grating, the image of the object photographed is seen in colors, these colors being complementary to those of the object; the latter appears in its own proper colors when the negative is replaced by a positive. The spectrum of the electric light has been produced with this apparatus by the aid of a positive in its natural colors. It is necessary that the angle of the prism used should be so small that the length of each spectrum produced by it should be less than the length between each line, otherwise the spectra interfere with each other. Ordinary sensitive orthochromatic plates can be used, and the exposure required is very much less than with the interference method. The chief drawback at present is the necessity of using the identical apparatus in which the exposure is made to view the colors, but M. Lippmann suggests a method by which this difficulty may possibly be overcome.—Nature.

Distillation of Metals.—H. Moissan has found that all metals may be liquefied and distilled. The iron family require very heavy currents in the electric furnace, but even tungsten and molybdenum may be regularly distilled. Boron and carbon, on the other hand, pass direct from the solid to the gaseous state. Brought to the temperature at which carbon evaporates, titanium is liquefied. The author has distilled 17 grammes of titanium in six minutes. A difficulty lies in the avidity with which titanium combines with nitrogen. The author draws some conclusions with regard to the temperature of the sun, which is known to contain titanium. On account of the large amount of heat radiated by the sun, it appears probable that it contains some solid matter as well as gaseous matter. At atmospheric pressure, no solid matter can exist at temperatures superior to that of the electric arc—i. e., 3,500 deg. Under the pressures available within the body of the sun, there will be much solidification, so that bodies can remain solid at temperatures higher than that of the arc. It follows that the temperature may be higher, and that at the surface of the sun it may amount to the 6,590 deg. given by Wilson.—H. Moissan, Comptes Rendus, March 19, 1906.

THE DESIGN AND CONSTRUCTION OF A 100-MILE WIRELESS TELEGRAPH SET.*

By A. FREDERICK COLLINS.

NOT long ago the writer was called upon to design a wireless telegraph set that should possess the following qualities: (a) To operate a guaranteed distance of 100 miles over water; (b) to be as nearly fool-proof as possible, and (c) to have the initial cost and upkeep of the equipment as low as would be consistent with good service.

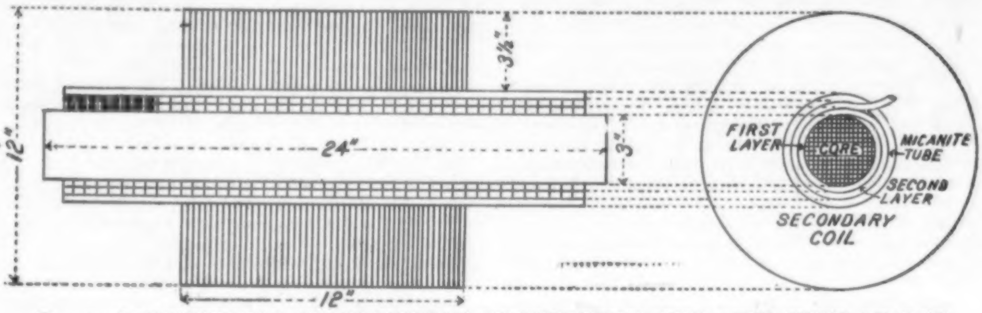


FIG. 1.—LONGITUDINAL CROSS SECTION OF INDUCTION COIL. END VIEW OF COIL.

These conditions were not very difficult to fulfill if we except the second one cited, for there is no device more sensitive to the unaccustomed touch of a green operator than a wireless transmitter and receptor, and I have on several occasions been called a distance of several hundred miles to "repair" some faulty equipment only to find that the spark-gap was drawn too long, the insulation of the oscillation circuits was defective, or, as it occurred in one instance, the binding post of the local cell had worked loose.

It is, of course, obvious that no system can be protected absolutely against these untoward occurrences, and that after the instruments are properly installed and adjusted the success of the service is left to the skill of the operator. The second stipulation was therefore disregarded except in so far as it was possible to impress upon the manufacturers the necessity of securely soldering every possible connection and of furnishing explicit working directions that the average operator could not fail to understand.

FIG. 2.—METHOD OF CONNECTING TERMINALS OF SECONDARY COIL.

While a plain open-circuit aerial system would, it must follow, be more simple and a little less expensive, it would also be less efficient, and this consideration outweighing the others, rendered a tuned and syntonized system advisable. It was further decided to employ an induction coil as a transformer for the transmitter and an auto-detector of the microphone type for the receiver. The use of these devices would greatly reduce the initial cost of the outfit as well as simplify matters, for if an alternating current transformer was used, then a generator and a gas-engine would also be required, while a microphone detector in conjunction with a telephone receiver supplants the coherer and Morse register and effectually eliminates the trying adjustments of the latter.

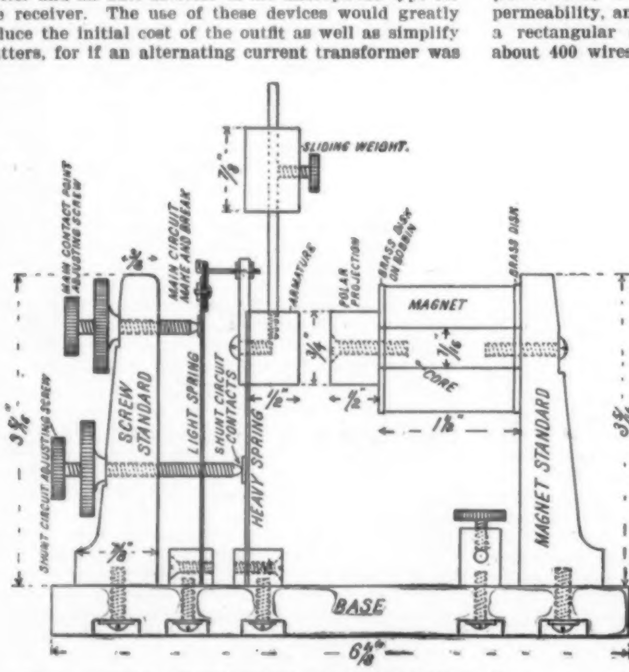


FIG. 3.—SIDE ELEVATION OF INDEPENDENT INTERRUPTER.

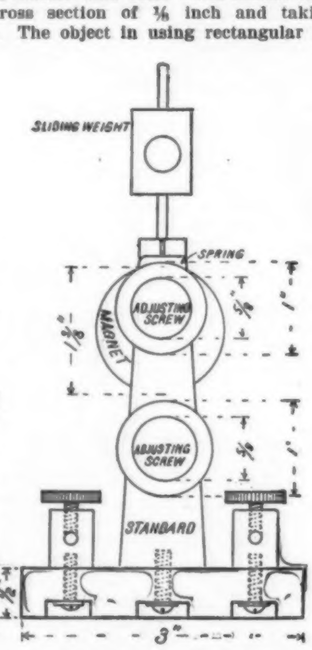


FIG. 4.—FRONT ELEVATION OF INDEPENDENT INTERRUPTER.

The transmitter, then, was designed to include: (a) An induction coil, (b) an independent interrupter, (c) a condenser for the coil, (d) an adjustable spark-gap, (e) a Morse key and its condenser, (f) a battery of Leyden jars, (g) a variable induction coil, (h) an aerial switch, and (i) a primary battery.

(a) The induction coil would ordinarily be termed a 10-inch coil, for coils are usually rated by the length of spark they give and not by the total output of energy; this is a very arbitrary method, for it only refers to the electromotive force developed and ignores the current strength. In the operation of X-ray tubes high potential currents may be desirable, but in wireless transmission the conditions are reversed and the electric oscillations must have "quantity" as well as "intensity"; in fact, the latter may be comparatively low. To restate the proposition, a long, thin spark is not an efficient producer of electric oscillations, nor is a coil giving such a spark a suitable device for a wireless telegraph sender. What is wanted is a short, heavy spark, and the proportions for the coil given below will, when assembled, produce a maximum spark 10 inches in length, possessing the rich qualities which are requisite for the conversion of the kinetic energy of the oscillations into powerful and penetrating electric waves.

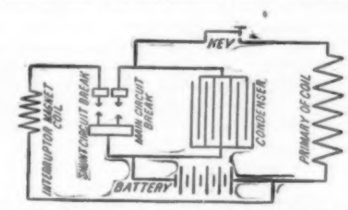


FIG. 5.—WIRING DIAGRAM OF PRIMARY COIL INTERRUPTER AND CONDENSER.

The core of the coil has a length of 24 inches and a diameter of 3 inches, as is indicated in the sectional drawing of the coil, Fig. 1. The core is given a larger diameter than is usual in ordinary coils, for when the mass of iron in the core is increased within certain limits the potential of the secondary rises in consequence, and this being the case the number of turns of wire on the secondary may be accordingly decreased. The original specifications designated that the core should be segregated—that is, made up of a bundle of wire of "dynamo magnet steel," namely, the purest iron, of uniform quality and highest magnetic permeability, and further that these wires should have a rectangular cross section of ⅛ inch and taking about 400 wires. The object in using rectangular instead of circular wire is to obtain as great a mass in as small a space as possible.

Ordinarily the primary coil is wound with double cotton-covered magnet wire in two layers, and for a coil of this size No. 12 B. & S. gage may be used; but by adhering to the following plan the sparking of the interrupter contacts as well as the size of the condenser may be somewhat reduced. To do this the primary conductor is formed of a number of smaller wires so that its conducting properties will be equal to a single No. 12 wire. About 125 turns are wound in each layer and when this is completed it is treated to a good coat of insulation varnish.

In this coil instead of using very fine wire for the secondary it is wound with approximately 25,000 feet of No. 28 double insulated cotton-covered magnet wire,

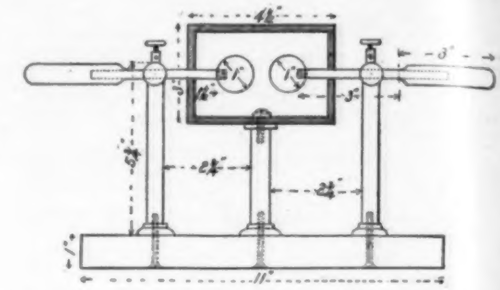


FIG. 6.—SIDE ELEVATION OF SPARK GAPS.

weighing in the neighborhood of 12½ pounds. The secondary coil is built up in the usual manner—that is, by drawing the wire through an insulating compound of melted resin and beeswax and reeling it into sectional disks 3/16 inch in thickness. The disks are then connected so that the outer terminals of the first two sections are joined together and the inner terminals of the next two and so on as shown in the diagram, Fig. 2. This relieves the static strains between the

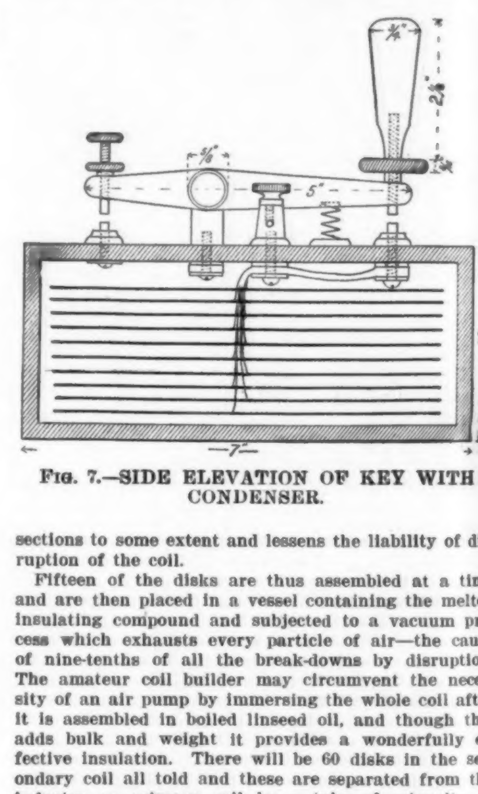


FIG. 7.—SIDE ELEVATION OF KEY WITH CONDENSER.

sections to some extent and lessens the liability of disruption of the coil.

Fifteen of the disks are thus assembled at a time and are then placed in a vessel containing the melted insulating compound and subjected to a vacuum process which exhausts every particle of air—the cause of nine-tenths of all the break-downs by disruption. The amateur coil builder may circumvent the necessity of an air pump by immersing the whole coil after it is assembled in boiled linseed oil, and though this adds bulk and weight it provides a wonderfully effective insulation. There will be 60 disks in the secondary coil all told and these are separated from the inductor or primary coil by a tube of micanite as long as the core, ⅛ inch thick and having an outside diameter of 3⅝ inches. Over this is slipped the

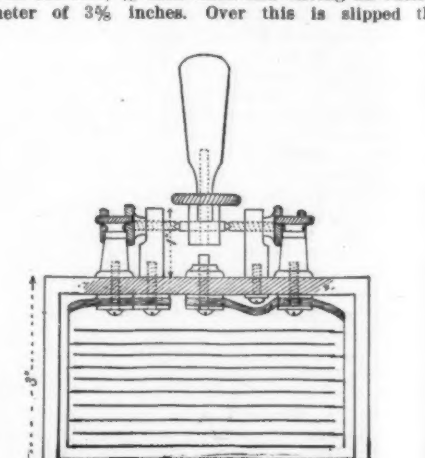


FIG. 8.—END VIEW OF KEY.

secondary coil, the latter having an inside diameter of 3¾ inches, an outside diameter of 12 inches, and an approximate length of 12 inches.

(b) The interrupter is of the independent spring vibrating type and provides a long "make" and a very sharp "break." Unlike the usual spring interrupter its period of vibration may be varied within certain limits. It is mounted on a base separate from

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

that of the coil and condenser. Fig. 3 is a side elevation and Fig. 4 a front elevation drawn to scale, and in which each part is plainly indicated. The standards supporting the magnet and the adjusting screws and the blocks to which the springs are attached are all of brass. The electro-magnet is wound with No. 30 double cotton-covered magnet wire until the bobbin is full. The ends of the bobbin are of brass and the

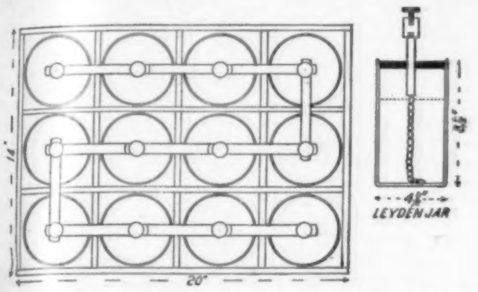


Fig. 9.—PLAN VIEW OF BATTERY OF LEYDEN JARS.

core and polar projection of the magnet are of soft iron. The heavy spring to which the armature is secured is 3 inches in length, ½ inch wide, and 1/32 inch thick. It is through this and the lower adjusting screw that the make and break of the shunt circuit takes place. The light spring is 3¼ inches in length, ½ inch wide, and 1/64 inch thick, and through this and the upper adjusting screw the main primary circuit is broken. Through this spring, 1½ inch from its base, a hole ¼ inch in diameter is cut to permit the lower adjusting screw to pass through without making contact. The upper screw is tipped with a contact point of platinum ⅛ inch in diameter and ¼ inch in length, while the spring has a disk of platinum 1/16 inch thick and 3/16 inch in diameter screwed to it. The armature carries a vertical rod 3/16

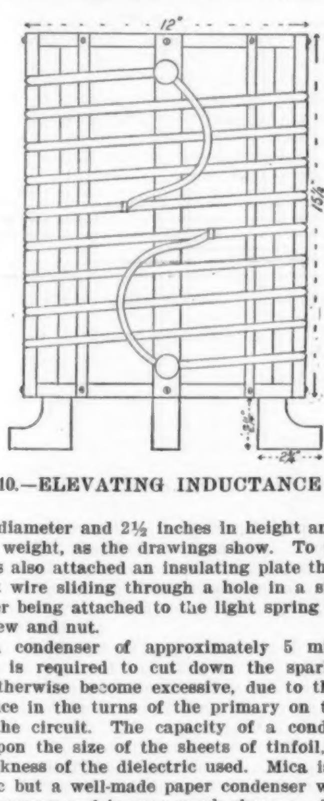


Fig. 10.—ELEVATING INDUCTANCE COIL.

inch in diameter and 2½ inches in height and on this slides a weight, as the drawings show. To the heavy spring is also attached an insulating plate that carries the bent wire sliding through a hole in a steel plate, the latter being attached to the light spring by means of a screw and nut.

(c) A condenser of approximately 5 microfarads capacity is required to cut down the sparking that would otherwise become excessive, due to the rise of inductance in the turns of the primary on the breaking of the circuit. The capacity of a condenser depends upon the size of the sheets of tinfoil, the kind and thickness of the dielectric used. Mica is the best dielectric but a well-made paper condenser will suffice for the purpose and is very much cheaper. The latter

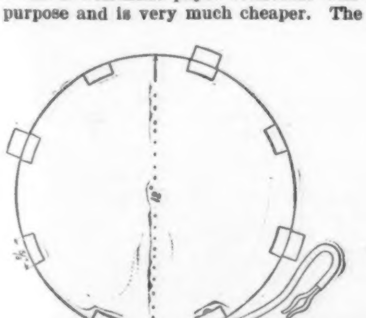


Fig. 11.—TOP VIEW OF INDUCTANCE COIL.

requires 64 sheets of tinfoil 7 × 12 inches laid on alternate sheets of oiled paper 9 × 14 inches, after which it is immersed in a bath of melted insulation compound, and before this has cooled it is subjected to pressure. In order to obtain the best results the condenser is made up of five sections and these are coupled together in parallel and the coil tried out with the current strength and voltage that is to be used in practice; when the number of sections that give the maximum spark length is found the condenser is placed in a case with binding posts. The primary of the coil, the interrupter and the condenser are connected up, as shown in Fig. 5, the initial energy being supplied by a battery of Edison-Lalande cells.

(d) The adjustable spark-gap is shown in Fig. 6 in elevation, and is mounted on a separate base. The standards supporting it are made of hard rubber ½ inch in diameter and 5¾ inches long. The hardwood box is 3 × 3 × 4½ inches and has a glass front, so

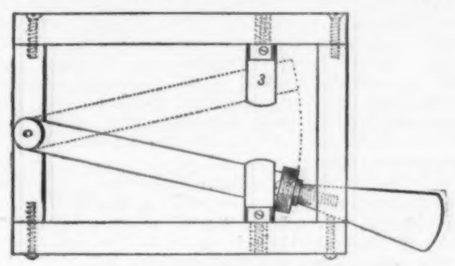


Fig. 12.—SIDE ELEVATION OF AERIAL SWITCH.

that the spark may be observed and yet the sounds of the disruptive discharge deadened. The spark gap balls are 1 inch in diameter, fitted to brass rods sliding through the standards, and are provided with hard rubber handles.

(e) The key is an enlargement of its prototype, the ordinary Morse key, except that it has no switch attached and that a condenser is shunted around the contact points. Figs. 7 and 8 are front and side elevations respectively, and a reference to these will show its dimensions and construction. The lever of the key is of brass and set in pivoted trunnions, also of brass, as are likewise the set screws and contacts; the latter do not need to be tipped with platinum, as they are made large enough to carry 15 amperes continuously without injury. A hard rubber button protects the hand from coming in contact with the lever when the handle, also of hard rubber, is manipulated. The condenser in the base of the key may be made of 40 sheets of tin foil 4 × 6 inches with intervening

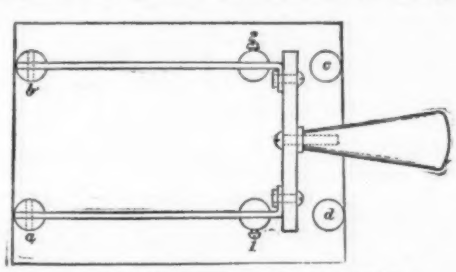


Fig. 13.—PLAN OF AERIAL SWITCH.

paper dielectrics 5 × 7 inches, built up and treated as in the case of the condenser for the coil.

(f) The high-tension condenser comprises a battery of twelve ½-gallon Leyden jars. These are made by coating the inside and outside of the jars with the tinfoil to within one-fourth of the tops and then giving the remaining exposed glass several coats of shellac varnish. Each jar will have an approximate capacity of 1/50 microfarad, and the total capacity of the battery will be 12/50 microfarad. Six of the jars connected in parallel will give the closed oscillation circuit a capacity equivalent to a 50-foot aerial wire. The jars are set in a case divided into compartments and lined on the bottom with tin foil so that all the outer coatings are connected together, as shown in the plan, Fig. 9. The inner coatings are connected by cross-bars of brass supported on brass rods ¼ inch in diameter and 4 inches long inserted in circular pieces of wood fitting tightly in the mouths of the jars. To the rods are soldered small lengths of chain that make contact with the foils inside. The jars are thus connected in parallel and the battery made adjustable.

(g) The inductance coil is formed of an octagonal

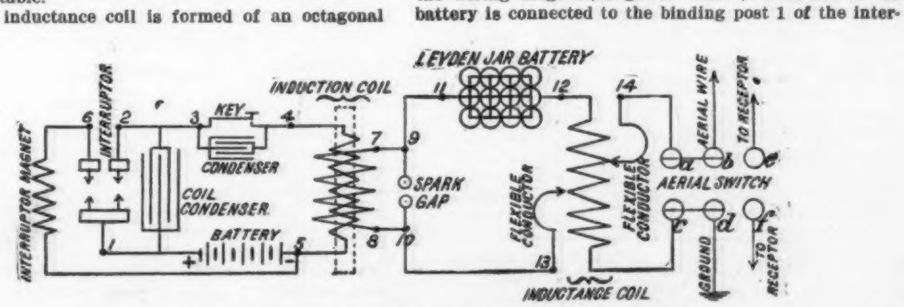


Fig. 14.—COMPLETE WIRING DIAGRAM OF TRANSMITTER.

frame, the top and bottom being made of hardwood disks 12 inches in diameter and ½ inch thick. To these are screwed eight hard rubber strips, each of which is 15½ inches long, 1¼ inch wide, and ½ inch thick, set in flush with the periphery of the disks, as shown in the elevation, Fig. 10, and in the plan, Fig. 11. The strips have recesses ⅜ inch wide cut at intervals of 1 inch across their faces, so that the inductance coil, which is made of 10 turns of bare copper wire having a diameter of ⅜ inch, will form a helix and at the same time will be rigidly supported in place and set flush with the outer surfaces of the strips.

The terminals of the coil are attached to the strips by metal cleats. At the top and bottom of one of the hard rubber strips binding posts are secured and from these lead two flexible insulated conductors 8 inches in length and ending in spring clips so that a quick connection or adjustment may be made with any of the other turns or portion of any single turn of inductance. One turn of inductance in the closed

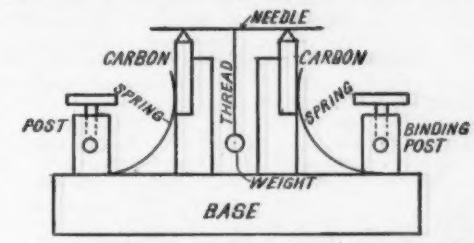


Fig. 15.—CROSS SECTION OF MICROPHONE DETECTOR.

circuit is roughly equivalent to an aerial wire 50 feet in length.

(h) The aerial switch, as it is termed, serves to disconnect the aerial wire and earth terminal from the receiving instruments when the operator is sending a message, and *vice versa*. Its construction is shown in detail in the side elevation, Fig. 12, and plan, Fig. 13. The blades of the switch are insulated from each other by the connecting bar of hard rubber. The four binding posts, 1, 2, 3, 4, are mounted on a hard rubber base, and the top, of the same material, is supported by the standards, *a*, *b*, *c*, *d*, Fig. 13, to which both top and base are screwed. To the rear standard, *a*, to which one of the switch blades is pivoted, the

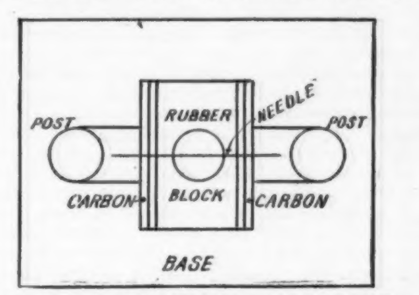


Fig. 16.—TOP VIEW OF MICROPHONE DETECTOR.

Fig. 17.—HEAD TELEPHONE RECEIVER.

aerial wire is connected, while to the opposite standard, *b*, the earth wire is permanently fixed.

(i) The energizing battery is formed of thirty-five Edison "type W" cells (formerly known as the Edison-Lalande). It is one of the best primary cells for operating induction coils and for wireless telegraph work, as each cell will give a maximum current of about 15 amperes; on continuous runs it has a limiting capacity of 7 amperes, but on short circuit will deliver 35 amperes. The electromotive force of each cell is approximately 7/10 volt and for the coil cited it would require a battery of about 35 cells coupled in series. The "type W" cell has a capacity of 600 ampere hours, when it must be renewed.

The different parts of the transmitter having been completed, they are connected together, as shown in the wiring diagram, Fig. 14. The + terminal of the battery is connected to the binding post 1 of the interrupter; the post 2 of this device leads to the post 3 of the key, which is then joined to the primary winding of the induction coil through the post 4. The opposite terminal of the primary leads to the — terminal of the battery. The shunt in which the interrupter magnet is placed is made through the binding posts 5 and 6. This completes the low-tension circuit.

The secondary terminals 7 and 8 lead to the posts 9 and 10 on opposite sides of the spark gap, and this

forms the high-potential charging circuit. The spark gap is included in the closed oscillation circuit, one side being connected to the post 11; the upper end of the inductance coil connects with the Leyden jars by means of the post 12. The closed circuit is completed through the flexible conductor which is connected to the post 13, and this is joined to the post 10. The upper binding post of the inductance coil 14 is connected to the post *a* of the aerial switch, which, when sending, leads to the aerial wire through the standard *b*. The lower end of the inductance coil is connected to the aerial switch post *c*, whence it is grounded through the standard *d*.

The receptor comprises the following parts: (*a*) A

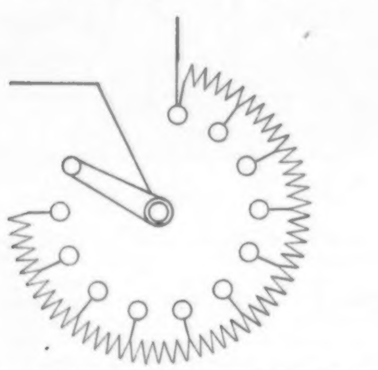


FIG. 18.—DIAGRAM OF CONNECTIONS OF RHEOSTAT.

microphone detector. (*b*) A head telephone receiver. (*c*) An adjustable 10-ohm rheostat. (*d*) An adjustable 150-ohm rheostat. (*e*) A variable inductance coil. (*f*) A fixed 0.1-microfarad condenser. (*g*) Two 1.5-volt dry cells. (*h*) A small switch.

(*a*) In recent wireless telegraph practice the autodetector and the telephone receiver have almost completely supplanted the filings coherer and Morse register. This evolution may be easily accounted for since the first-named is at once simple, reliable, and does not limit the speed of reception, while the last-named is notoriously at fault in these respects.

An auto-detector was used for this set in virtue of the foregoing reasons and one of the microphone type selected, since it requires practically no adjustment and is, next to the electrolytic detector, the most sensitive known. This effective detector is made as follows: Flat pieces of carbon ⅛ inch thick, such as are used on dynamos and motors for brushes, are cut into rectangles ¾ inch wide and 1¾ inches long, and one edge of each is ground sharp. A hard rubber block 1 inch high, 1 inch wide, and 1¼ inches in length has a recess cut lengthwise on each of its upper sides ⅛ inch deep and ½ inch wide; into these are placed the carbons, which are held in position by brass springs ½ inch wide and 1¾ inches long, the ends of these being secured to the base by binding posts so that they also serve as conductors for the electric oscillations as well as the current from the dry cells.

Through the vertical center of the block, a hole ½ inch in diameter is drilled. An ordinary swing needle, say a No. 7, is placed across the sharpened edges of the carbons. To the middle of the needle is attached a silk thread and to the free end of this and at a distance of 1 inch from the needle is secured a lead bullet weighing 15 grains. The needle must be adjusted so that the bit of lead does not strike the walls of the well in which it swings. The whole arrangement of the detector is made clear by the

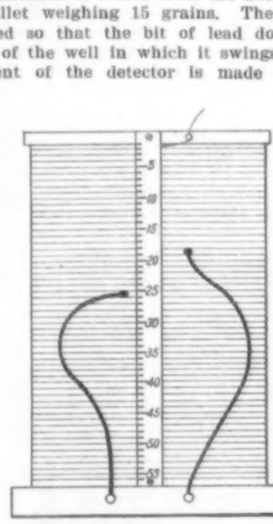


FIG. 19.—RECEIVING VARIABLE INDUCTANCE COIL.

cross sectional drawing, Fig. 15, and the top view, Fig. 16.

(*b*) The telephone receiver used in conjunction with the detector to indicate the messages is of the double-pole switchboard type and is wound to 40 ohms resistance. The spring has an adjustment that can be set to hold the receiver firmly to the ear of the operator. It is illustrated in perspective in Fig. 17.

(*c*) The 10-ohm rheostat is made of ten 1-ohm resistance coils connected together in series, as shown in Fig. 18. Each coil is made up of 5 feet of No. 20 double cotton-covered German silver wire wound non-inductively in a helix 2 inches long, ¼ inch in diameter, and having an approximate resistance of 1 ohm. At the junction where the terminals are coupled together, a heavy copper wire is soldered and the free end of this is connected to a button or point that projects outside the case inclosing the coil. The points are arranged in a semi-circle and a small lever moving progressively over them serves to cut in or out the resistance.

(*d*) The 150-ohm rheostat is made of fifteen 10-ohm coils, each containing 5 feet of No. 30 double-insulated German silver wound in a helix 2 inches in length, ¼ inch in diameter, and each having an approximate resistance of 10 ohms. These are arranged exactly like those of the 10-ohm rheostat except that there are fifteen points or steps. The 10-ohm and 150-ohm resistances are placed on opposite sides of the receiver case.

(*e*) The receiving variable inductance or timing coil is made by winding 110 turns of No. 16 B. W. G. bare tinned copper wire around a light cylindrical frame of wood well shellacked and having a circumference of 36 inches and a height of 16 inches; the turns are wound helically and are separated from each other by ⅛ inch. The upper end of the tuning coil is connected with a binding post to which the aerial wire leads through the aerial switch. The lower end of the coil is free, but on either side of the base are binding posts and to each is attached a flexible conductor 15 inches in length, these ending in small metallic plugs which can be easily shifted to any position. The construction of the coil is shown in the elevation, Fig. 19.

As each turn has an effective inductance equal to a straight wire 40 inches in length, due to winding, it is possible to use an aerial wire 116 yards in height and to time to a wave length up to 464 feet. A scale having a division for every turn with every fifth turn numbered is attached vertically to the coil as shown.

(*f*) A small condenser made of twelve sheets of tin foil 3 × 4 inches interposed between oiled or paraffined paper is placed between the detector and the earth.

(*g*) Two small Mesco dry cells giving a total of 3 volts are connected in circuit with the detector and telephone receiver.

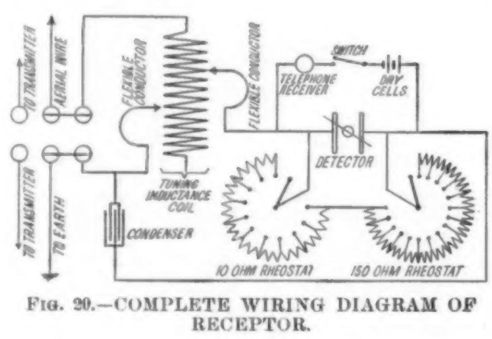


FIG. 20.—COMPLETE WIRING DIAGRAM OF RECEPTOR.

(*h*) A small lever switch to be placed in the same circuit.

The foregoing appliances having been procured they are connected together as shown in the wiring diagram, Fig. 20. When the lever of the aerial switch is thrown over for receiving, the aerial wire is brought into connection with the inductance coil through its upper binding post, 1; the closed circuit is continued through the flexible conductor *a*, ending in the binding post 2 at the bottom of the coil. To this post the microphone detector is connected by the post 3, its opposite post 4 leading to the condenser 5 which connects with the flexible conductor *b* and to the earthed terminal through the post 6. The telephone receiver, switch, and dry cells are connected in series and then bridged across the detector through the posts 7 and 8. Also in shunt with the detector are placed the potentiometers or rheostats which are led off from the posts 3 and 4.

This completes the sending and receiving apparatus of a set that will, with an aerial wire 180 feet in height and properly earthed plates, give a signaling range of 100 miles over salt water, provided they are accurately adjusted.

THE PROPERTIES OF TUNGSTEN FILAMENTS.

THE fundamental value of tungsten for incandescent lamps lies in its enormously high point of melting, or volatilization, as there is some doubt about its actually melting prior to passing into vapor. In this respect it perhaps resembles carbon and the non-metallic elements, as should indeed be expected from its chemical position. As a metal in the common sense of the word, tungsten is unknown. It has not yet, for instance, been reduced to an ingot from which anything could be hammered or cut or drawn, and perhaps it never can be so treated. Therefore, so far as is now known a filament of wire such as is used in the tantalum lamp cannot be produced from tungsten, and the filaments made for use in the tungsten lamps have to be obtained by roundabout methods, and when completed are, like carbon filaments, aggregates of amorphous structure or of infinitesimal crystals. The processes in use for making the filaments seem to be of three distinct kinds. The first is the outgrowth of attempts to coat a carbon filament with tungsten after the manner tried in the work on osmium lamps. It results in the simultaneous dissolution of the carbon filament and its replacement by finely divided tungsten further strengthened by a process akin to flashing, i. e., the still further heating of the filament in the vapor of a tungsten compound.

The other two processes start with very finely divided tungsten and consist in making a paste from which the filaments are formed. Further treatment is given by firing. The earlier processes deal with a paste made as it were of precipitated tungsten; the later one starts with the so-called colloidal metal which presents the advantage of almost infinitely fine subdivision. Whether the filament is prepared by the substitution process, the paste process or the colloid process, the result is of the same character—a thread perhaps 1 to 2 mils in diameter of compactly aggregated pure or nearly pure tungsten. These filaments are dense and of smooth and uniform appearance, but thus far have seemed to be very brittle, as might be anticipated from their structure. The elimination of this excessive brittleness is the crux of the tungsten lamp problem. The filaments can be worked at one watt per hefner (the value of the hefner according to a recent Reichsanstalt determination is 0.909 candle), or thereabout, with a life that is claimed to be one to two thousand hours, with exceptionally small loss of illuminating power. Indeed, some tests have shown an actual increase of efficiency after several hundred hours of use. It appears to be extremely difficult to produce lamps of the ordinary voltages and moderate power.

The specific resistance appears to be quite low as compared, for instance, with osmium or tantalum, so that the filament in a tungsten lamp is both long, requiring several loops in series, and extraordinarily slender. Like the osmium filament it seems rather plastic when hot and must, so far, be burned in a vertical position. The intrinsic brilliancy is very great as compared with any other incandescent lamp and the light is probably as nearly pure white as can be obtained. The extreme fineness of filament required for lamps of ordinary power suggests that the best use of the material at present is for lamps of large candle power, which would prove invaluable in replacing the blue flickering arcs of small amperage. A final result of this condition may be the displacement of the present inadequate 16-c.p. unit by 25 or even 40 c.p., thus placing the electric lamp in a better position with respect to the Welsbach. It is, of course, quite impossible to predict the probable growth of the tungsten lamp. It is new and promising, but has many difficulties to contend with before it can find its full place. It is now far enough along, however, to say with confidence that it will find important use, if only for large units. Its general use hinges on the success with which the filaments can be made for moderate candle power without prohibitive breakage; and many recent tests, we believe, point that way, and justify confidence in the new illuminant as an enormously beneficial factor in the incandescent lighting field. In any event, the carbon filament may soon be a thing of the past.—Electrical World.

RADIATION FROM GAS MANTLES.*

By J. SWINBURNE.

THE ordinary explanation of the great luminous efficiency of the gas mantle is that rare earths have a property of selective radiation, in virtue of which they send out a larger proportion of their radiant energy in the form of light than ordinary hot bodies. The rare earths also suffer from "luminescence," which may be a disease on its own account, or a symptom of catalysis, or polarization or something.

Another explanation, first given, I believe, by Ram ("Incandescent Lamp," p. 196), is that the Bunsen flame is really very hot, and that the mantle is of such low emissivity that it gets rid of so little power that there is little difference of temperature between it and the flame, and it is, therefore, hot enough to give the light by pure temperature radiation, without any anomaly.

One reason why the simple temperature explanation has been much questioned, and generally rejected, is that the temperature of the Bunsen is generally taken to be much lower than it is. It is generally measured by means of platinum wires or thermo couples. These can never rise to the real temperature of the flame, as they are radiating, and must, therefore, be taking in heat by conduction, in which case they must be cooler than their surroundings.

The simple temperature explanation fits the phenomena. If pure thoria has low emissivity it will rise to a temperature near that of the shell of flame bathing it. Having low emissivity it will then give out little light, but the light will have a larger proportion of visible and refrangible rays. If a very little of a body with a high emissivity be added, radiation will increase, but the temperature of the mantle will fall, as there must be a steeper heat gradient to supply it. The total radiation is then increased, and though the proportion which is luminous will be diminished, the total light will be increased. Further addition of the emissive substance increases the total radiation and reduces the temperature until the light given is less even than with pure thoria.

It may be urged against this that thoria, zirconia and alumina, for example, are white, and therefore may be expected to have little luminosity when hot, as a white body being a good reflector should be a bad emitter; but ceria, if pure, is also white, about as white as thoria, and, therefore, should have the same order of emissivity as thoria, and adding 1½ per cent

* Paper read before the British Association, Section A, at York.

of it cannot, therefore, increase the emissivity of the mantle very much. But it does not follow that a body which is white when cold necessarily remains white when hot. Zinc oxide, for instance, gets yellow when hot, and ceria may emit like a dark-colored body when hot. According to Féry it has a much greater emissivity both for heat and light than thoria. The ceria of chemistry books is white, but the ceria of commerce is yellow.

Almost anything colored, however, increases the light of thoria if added in very small quantities. The reason why ceria is used is not that it has any peculiar radiating qualities; it is chosen because it is fairly permanent at the high temperatures, and does not weaken or spoil the thoria mantle. The earlier mantles were of zirconia and yttria in the proportion to make a normal zirconate. Zirconia alone gives very little light, and makes a bad mantle mechanically. The yttria would contain erbia if separated by potassium sulphate. When lanthana was used it would probably contain didymia, and perhaps ceria.

The light of the mantle may thus be purely that due to a hot body at a given temperature, the proportion of components of different frequencies being simply that due to the temperature. The addition of a little more ceria would then increase the emissivity and cause greater radiation, and a fall in temperature so that the light would decrease. A decrease of ceria would diminish the emissivity, so that though the mantle became hotter, it would radiate less of all wave lengths.

Though this simple explanation may be ample, it does not follow that there may not be all sorts of curious things, such as selective emission, luminescence, catalytic action, resonance, unstable oxidation, and other occurrences, whose names are as impressive as vague.

They may be discussed in turn.

By selective radiation may be meant that a body at the temperature of a black body emits some rays and omits others, or that it has the power of emitting more refrangible rays than a black body at the same temperature. If two black bodies are in a reflecting envelope, at the same temperature, each radiates to the other, and absorbs power from the other. The heat in each is in a state of degradation corresponding to the temperature, and in a state of equilibrium it must be radiated and absorbed by each without further degradation. Heat radiated from a black body into a closed space in equilibrium is thus not degraded. If a body only emits the portion of the rays of high frequency, though it may radiate less power or energy per second, that energy would seem to be of a higher grade than that of the black body at the same temperature, so that it can be degraded into radiation of lower frequency. If that is so, this sort of selective radiation violates the second law. Emitting more refrangible rays than the black body is worse still. It does not follow from this that a body cannot emit rays of high frequency balanced by another batch at low frequency, so that their degradation corresponds with the temperature. This form of selective emissivity has not been invented by the advocates of this theory.

There does not seem (at present) to be any thermodynamic reason why a hot body should not radiate a selection of rays provided the energy radiated is not less degraded than the heat in the body, or to put it the other way, as long as the energy has no increased "motivity," to use Kelvin's term. For the radiant energy leaving the surface to have a higher motivity than the energy in the body is a violation of the second law. There is an interesting question as to whether the radiant energy leaving a hot surface can start with less motivity. I am not considering increase of entropy of radiation spreading out after it has left the surface, but whether there can be a sudden discontinuous degradation at the surface. Growth of entropy in the case of heat conduction, irreversible expansion and diffusion is a volume increase, and it takes place when the motion of the particles is not the same in all directions, or is not diffused. Thus in heat conduction the particles move quicker when going one way than when going the other, though the distance is the same each way. In diffusion the motion of the particles of the fluids are on the whole directional. Here the speed is the same, but the distance different. Similarly with radiation in space. It seems open to question whether there can be a sudden or discontinuous change of motivity as the energy crosses the surface, changing from sensible heat into radiation. Stokes's law, that a fluorescent body cannot give out radiation on the whole of a higher refrangibility than the radiation that induced it, does not seem to have been proved, but seems to have been rather a sort of automatic statement, unconsciously based on knowledge, sounding as if it must be right.

It may be said that an ordinary spirit or Bunsen flame does not give any light to speak of, though it is hot enough to incandesce a mantle, and it certainly radiates a great deal of heat; and though it is not a surface, if its radiation has less motivity than the hot gases, there must be discontinuous increase of entropy there—perhaps. But, on the other hand, it may make up for its low-frequency radiation by some very high; and the blueness of the flame is significant. Again, in a flame it may be the slower moving particles that combine.

Another theory, very much to the fore in connection with electric lamps, is that different surfaces have different radiating efficiencies. The experimental evidence on this point is very conflicting, and the conclusions are often, I submit, unsoundly drawn. There is direct evidence, due to Féry, that the emissive light efficiency—candles per watt—varies enormously. At 1,400 deg., for example, taking the efficiency of a perfectly black body as 1, lanthana is 17, thoria 9, thoria-ceria mantle 7, platinum 5, chromium oxide 4, carborundum 3, carbon 1.3. On the other hand, chromium oxide and ceria in the reducing flame radiated more total heat per second than a black body, an absurdity which the author himself was the first to criticise. There is apparently a clear instance of selective or preferential emission in the case of erbia. In the flame it shows bright bands in the green. I have not tried a Nernst rod of it.

The next theory is that the mantle gives more light than that due to a simple hot body owing to luminescence. I cannot deal with this theory, because I have no clear idea what luminescence is. If by luminescence is meant the phenomena of a mantle, it is no explanation of the phenomena to call them luminescence.

Catalytic action is also a little vague. The idea often seems to be that, by some action or other, the ceria can convert energy of chemical action directly into light. It must be remembered that chemical energy is not work; it is partially degraded, and may be best regarded as heat, of which only a portion, $(\theta - \theta')/\theta$, can be converted into work. No catalytic action can restore chemical energy to a higher grade. But many of the chemists who advance the catalytic action theory are not men who would make slips of that sort.

The catalytic argument may, perhaps, be put something like this: If a mixture of gas and air is above ignition temperature, and is inclosed in a case from which no heat can escape, the speed of the chemical action will depend on the temperature, the pressure, and the relative amount of air, of fuel, and of combined product. We will take the pressure as constant. The rate of combination then depends on the combustion already completed. Suppose now the combustion takes place in a flame; let us consider a small volume of burning mixture ascending. It can now radiate heat, and the temperature corresponding to a given proportion of fuel burned is lowered. If the reaction constant could be artificially increased, the flame would be hotter and would radiate more heat. The rate of radiation of heat keeps the flame temperature from rising to such a value, that the reaction constant is zero; or that the products dissociate as fast as the fuel burns. If ceria has the power, by catalytic action, of increasing the reaction constant, the ceria may be considerably hotter than the flame; and catalytic action may thus cause the mantle to give out rays corresponding to a higher temperature than the flame, though not to a higher temperature than that corresponding to the chemical action. There must always be some degradation of energy.

It is said that ceria acts in a special way by wobbling from one state of oxidation to another. It is quite clear that an oxide cannot create energy or heat or light by wobbling; moreover, it cannot be in equilibrium in both states. If it is in equilibrium in one state it cannot move out into a higher state. Again, chemists who put forward the oxidation theory are not likely to put it in such a form as this, so a more tenable proposition is to be sought. If the rate of combination depends on the collisions of suitable particles at suitable speeds, and if the lower oxide of cerium can hang on loosely to oxygen particles, so that it has a stock of them, any fuel particle hitting the ceria at a suitable speed can combine with oxygen. The ceria would thus heat the mantle above the temperature of the flame, or at any rate to a higher temperature than it would otherwise reach. As an analogy we may consider a matrimonial agency, with a number of women on its books. Any man knocking about who comes there meets a wife at once and combines, or is burnt at once, whereas had he merely knocked about until he met a suitable wife, the probability is that he would have been longer about it.

The next theory is that of "resonance." Particles of gas are vibrating and changing their velocity fast enough to produce light, but somehow do not produce it. Particles of solid, however, get set into vibration synchronously with the gas particles, and thus radiate energy of the same grade as the heat of the flame. But ceria is supposed to be specially timed to vibrate with frequencies corresponding to visible radiation, so it radiates more light than other solids. This really amounts to ceria doing the work of Maxwell's demon, except that it is working on waves instead of particles. It can get outside the second law just the same. Maxwell's demon is apt to come into radiation in many disguises. He is rather fond of being a very thin plate which lets only one wave-length through and reflects all others perfectly. I have seen him mixed up in proof of Wien's law in this disguise.

The explanation that there is nothing anomalous about the mantle, and that it gives light just because it is very hot, has a Jordan simplicity about it which makes it unpopular compared with the Ahana and Pharpar of luminescence and catalytic action; but, all the same, very simple explanations are very often wrong.

EARLY ILLUMINATING OILS.*

By Prof. C. F. Chandler.

There was a time when no one knew anything about electric ligthing and gas was a new thing. Sperm oil sold for \$1.75 a gallon by the cargo, and \$2.25 at retail fifty or sixty years ago, and the cost of artificial illuminants was one of the most serious items in domestic expenses. I remember in my early boyhood when they began to build the gas works at the foot of the street in New Bedford on which I lived. There were gas works in existence at that time, but they were confined to a few of the large cities. I spent much time in watching the operations as they dug the hole for the gas tank, built the benches, set the retorts and started the works; and when my father actually put pipes into the house and had burners put on, the light seemed most marvelous. In my boyhood we had nothing but oil lamps. I have in my museum in Columbia an old brass lamp with a little crooked handle on it, which my grandmother used. She would hold the little lamp between her eyes and the book she was reading to me, and that was artificial illumination in those days. Then there was an improvement. Some one conceived the idea of substituting camphene, refined spirits of turpentine, and that was introduced as a substitute for sperm oil. It was very inflammable and evolved a combustible vapor, and we had numbers of explosions from it; but it gave such a brilliant light and was so cheap, that people burned it and took the chance of the explosion and the terrible accidents which occurred, for the sake of getting something that was within their means. I do not remember the price, but it did not cost more than one-third as much as sperm oil. The difficulty was that it could only be used with a chimney. The turpentine is so rich in carbon that it gives a smoky flame, and it was necessary therefore to burn the camphene in a lamp with a chimney. But an ingenious chemist produced a satisfactory oil for portable lamps without chimneys by combining camphene, too high in carbon, with alcohol, poor in carbon, producing the so-called "burning fluid" which was used in high glass lamps, without chimneys, having two plain, unusually long wick tubes. These old "fluid" lamps are now being sought in all the old attics in New England and sold to the ladies, who have kerosene burners put on them and pretty shades and use them to decorate their tea tables. But I am afraid there must be a factory where they make them, as there are so many of them being discovered and sold.

I went to Germany to study chemistry. When I entered a German family, as a boy, in Berlin, there was a glass lamp placed on the table that held a queer looking oil. It had a smell different from sperm oil, and I inquired of my host what it was and he said it was a "Photogen" lamp. I inquired of my professor what this new oil was, and he said it was made from boghead mineral, which came from Scotland, and that parties in Scotland had begun to manufacture it on a large scale. I was so much interested that I immediately sought for information, and secured one or two pamphlets which had been published on the subject of this coal oil, giving an account of how the oil was manufactured from the boghead mineral, which came from Torbane Hill, Scotland. When I came home, in 1856, and told my New Bedford friends, who had their whale- and sperm-oil refineries and candle works, about an oil made out of a mineral dug out of the ground, they shook their heads and said that nothing could ever interfere with the prosperity of the sperm-oil industry. In less than three years after that, there was a series of coal-oil factories from Portland, Me., down to Wilmington, Del., manufacturing the so-called coal oil or kerosene. It was made out of the boghead mineral which came from Torbane Hill, Scotland; Albertite, which came from Nova Scotia; Grahamite, which came from Ritchie County, W. Va., and Breckinridge coal, which came from Breckinridge County, Ky. As soon as this coal oil made its appearance lamps were invented to burn it, and the price of the oil dropped down to 50 cents per gallon. The coal-oil industry was firmly established and light became much cheaper.

Then a couple of Yankees from New Haven went to northwestern Pennsylvania, where they saw oil on the surface of the ponds, and some of this oil was skimmed off the ponds and taken to New Haven to Prof. Silliman, who examined it and said it was nothing but crude kerosene oil. They asked him if it was useful, and he said that it certainly was if they could get enough of it. They went back to Oil Creek, in Pennsylvania, but did not dare to make any very definite bargains with the farmers. They prowled about and found places where there was scum on the water and made contracts with the farmers to gather the oil on a royalty. They gathered a few barrels of it and then selected a man, Col. Drake, and put him in charge, and organized the first petroleum company in the world, the Pennsylvania Rock Oil Company. Col. G. L. Drake was made the superintendent, and went to Oil Creek to take charge of the collecting of the oil. He learned that in 1819 oil was accidentally obtained in boring two salt wells on the Muskingum River in Ohio, and that in 1829 a flowing well was accidentally obtained at Burkesville, Ky. He became possessed of the idea that he might obtain oil by boring for it, so he erected a derrick and started to bore an oil well. The old farmers came from miles around to watch the boring operation, with a feeling that Drake might with equal reason bore for whisky. But on the 26th of August, 1859, he "struck oil" at a depth of 71 feet, and obtained 400 gallons, which he sold for 50 cents a gallon. Soon a forest of derricks sprang up, extending into West Virginia and Ohio. Successful wells yielded from 100 to 2,000 barrels of oil daily. The Noble well yielded in a little more than one year 500,000 barrels of oil; the Sherman well in two years 450,000 barrels, and petroleum became one of the most valuable productions of the United States. The yield in 1904 was over 100,000,000 barrels. To-day the price of refined petroleum for use in lamps is 5 cents a gallon in bulk.

* Part of the discussion which followed the reading of a paper before the Illuminating Engineering Society.

[Concluded from SUPPLEMENT No. 1604, page 25697.]

MODERN MANUFACTURE OF ALCOHOL.—III.*

Extraction of Alcohol from the Mash, or Fermented Wort.

THE fermented wort, in general, contains alcohol mixed with a large quantity of water and solid residuum in addition to glycerine, succinic acid, and fats which are by-products of the alcoholic fermentation and aldehydes, ethers, and higher alcohols produced by other fermentations. If only small quantities of these impurities are present it is possible to extract the alcohol, mixed with water but otherwise nearly pure, by a single distillation. Usually, however, the product of the first distillation (called in France "flegmes") contains many impurities which are removed, more or less perfectly, by physical and chemical processes and by re-distillation or rectification. The apparatus may be divided into three classes employed respectively in distilling, in rectifying and in distilling and rectifying at one operation.

Distilling Apparatus.—In almost all cases distillation goes on continuously throughout the distilling season, except for stoppages made necessary by clogging of the apparatus or other accidents. Of the very numerous types in use we select for description the Savalle apparatus for distilling grain spirit which is much used in France (Fig. 22).

The essential part of the apparatus is a square tower, *A*, divided into 25 segments by horizontal copper plates, and resting on a cast-iron base. This distilling tower is heated, usually, by steam admitted through the base at *V*. The vaporized spirit escapes at the top through the pipe *K* leading to the trap *B*, which removes froth and suspended solid particles. The mash flows, by gravity or otherwise, through the pipe *M M* to the tubular condenser heater *C*, which serves the double purpose of partly condensing the alcoholic vapors which come to it from the tower and warming the mash by the heat set free in that condensation. The flow of the mash is regulated by the cock *U*, furnished with an index and graduated quadrant, on a branch of the pipe *M M*. The heated mash flows from the surface of the liquid in the condenser-heater *C*, through the pipe *Q* to the top of the tower *A*, where it covers the uppermost plate to a depth of two or three inches. This plate, like each of its fellows, is pierced by two large rectangular apertures, *A* and *B* (Figs. 23 and 24) and two small square apertures *O O*. To the small openings are fitted short overflow tubes, the tops of which determine the level of the liquid on the plate while their lower ends nearly reach the plate below. The large openings are surrounded by rims somewhat higher than the efflux tubes, so that the liquid can never overflow through them, and are covered by caps which are so supported as to leave clearances between them and the plate as well as the rims of the openings. The edges of the caps dip into the layer of mash. In consequence of this arrangement the mash overflows from plate to plate until each of the plates is covered with a thin layer of the liquid through which the spirit evaporated from lower layers by the current of steam can pass only by bubbling under the edges of the caps that cover the large openings *A B*. Hence the vapors become cooled as they ascend and are coolest at the top of the tower. Conversely, the liquid becomes heated as it descends and is hottest at the bottom of the tower. At every level, however, the vapor is hotter than the layer of liquid that it traverses at that level. Consequently, the vapor is changed in constitution at each plate by taking up more alcohol which it evaporates from the layer of mash, and by losing water which is condensed by the mash. Hence the vapor attains its maximum alcoholic strength when it reaches the top of the tower, while the mash when it arrives at the bottom has lost practically all of its alcohol. At the same time many of the impurities are washed out by the many layers of liquid through which the vapor is forced to pass in bubbles which insure intimate contact over a large surface.

The distilled spirit after passing as vapor through the pipe *K* and the trap *B*, traverses the condenser heater *C* where it is partly condensed, and thence flows, as mixed vapor and liquid, through the pipe *S S* to the tubular condenser *D*, in which the condensation is completed by a current of cold water flowing from the reservoir *H* through the pipe *N*.

The condensed spirit is drawn off through the test gage *E*, which shows the yield and strength at any instant and thus gives indications for the control of the apparatus. This device will be described in detail in connection with rectification. From the test gage the crude spirit, or "flegmes," is distributed by pipes, according to quality, to different tanks to await sale or rectification. The exhausted wash or "vinasse" flows into the cylinder *G* from the top of which it is drawn off into permanent reservoirs.

A very important part of the Savalle apparatus is the steam regulator shown at *F F'* (Fig. 22) and separately in Fig. 25. This consists of a closed vessel, *F'*, connected by the pipe *J* with the distilling tower and by the vertical tube 2 with an upper chamber, *F*. The lower chamber is partly filled with water, a portion of which is forced into the upper chamber by the pressure of the steam. The float *X* in the upper chamber controls the valve *I* of the steam pipe, thus regulating the admission of steam to the tower in accordance with the total pressure of steam and alcohol vapor therein and keeping that pressure constant.

An apparatus of this type, 33 feet high, produces daily about 4,400 gallons of crude spirit, containing 50 per cent of absolute alcohol, from 30 tons of grain.

The height of the Savalle tower makes it unsuited to small establishments. The shorter Egrot tower contains only eight plates or segments, but the path of the distilled vapor is lengthened and its intimate contact with the liquid assured by its passage through

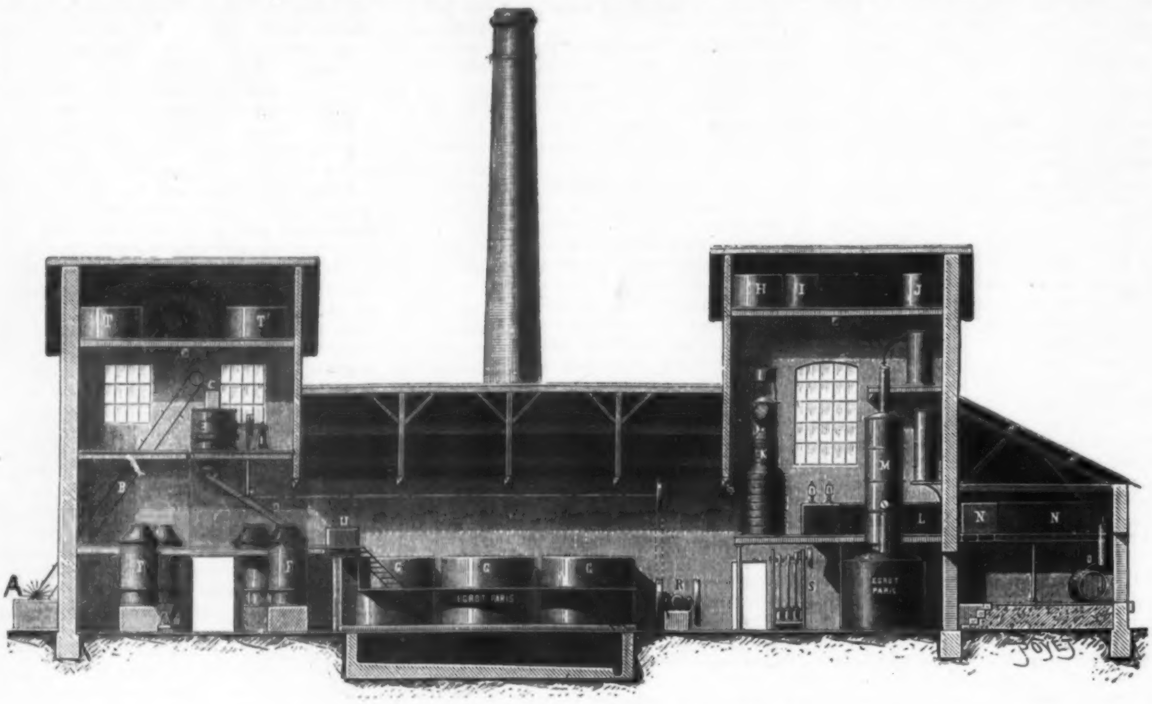


FIG. 21.—SECTION OF A BEET DISTILLERY.

A, Mashing tub; B, endless carrier; D, slicing machine; F F, infusion tubs; G G, fermenting vats; H, cold water tank; I, wine tank; J, hot water tank; K, distilling tower; L, crude spirit tank; M, rectifying tower; N N, alcohol tanks.

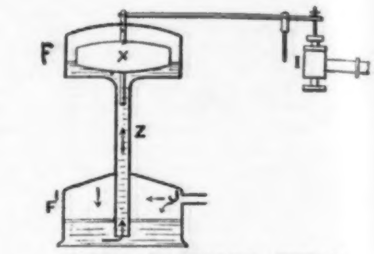


FIG. 25.—SAVALLE STEAM REGULATOR.

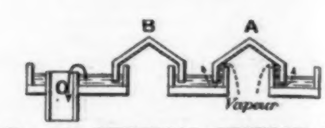


FIG. 24.—VERTICAL SECTION OF PLATE.

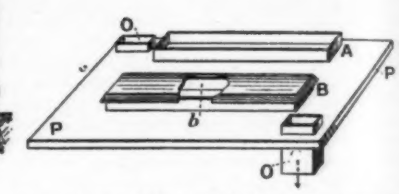


FIG. 23.—PLATE OF SAVALLE TOWER.

A B, Roofed openings for the passage of vapor; O O, overflow pipes.

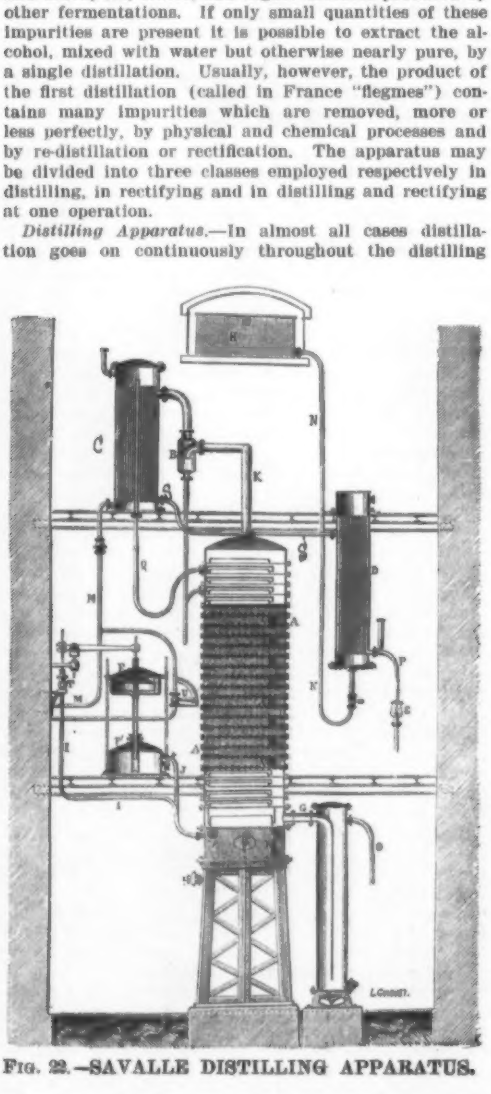


FIG. 22.—SAVALLE DISTILLING APPARATUS.

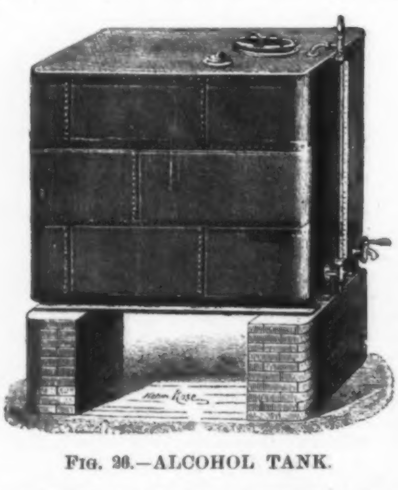


FIG. 26.—ALCOHOL TANK.

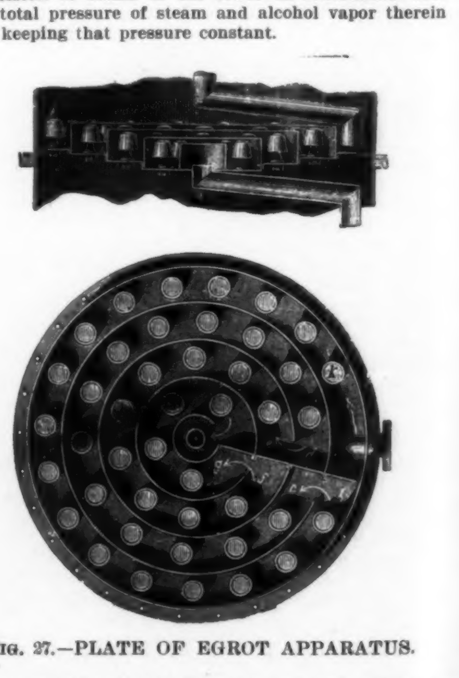


FIG. 27.—PLATE OF EGROT APPARATUS.

* Specially translated from "Sa Majesté l'Alcool," by L. Baudry de Saunier, for the SCIENTIFIC AMERICAN SUPPLEMENT.

numerous little traps, or "boilers," placed in the ring-shaped channels into which each plate is subdivided. The wine, cider, or fermented light wort (heavy worts cannot be used) flows through the outermost ring in the direction of the arrows until it reaches the radial

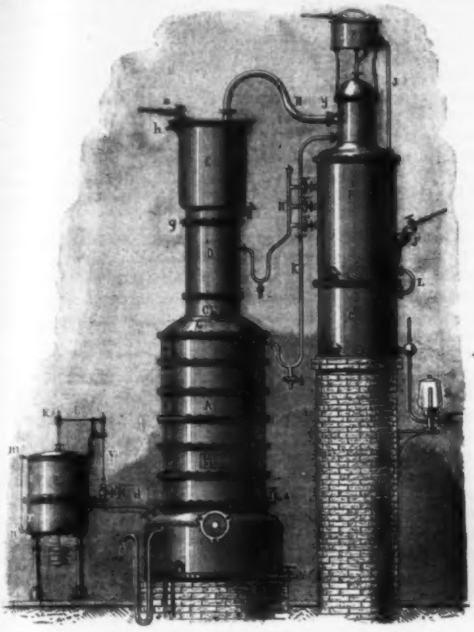


Fig. 28.—EGROT DISTILLING AND RECTIFYING APPARATUS.

A, Distilling tower; D, rectifying tower; E, supplementary rectifier for 90 per cent alcohol; F, condenser heater; G, main condenser; P, steam regulator; S, test gage.

partition and is deflected into the next ring through which it flows in the opposite direction. The stream winds through the maze of rings each of which is a little lower than the preceding until it reaches the center, whence a pipe conducts it to the outside ring of the plate below. The distilled vapors rise from plate to plate through the vertical tubes of the traps and escape in bubbles from the submerged edges of their caps.

Collette's apparatus has plates perforated with small holes and inclined to right and left alternately. The mash flows over the top plate and from its lower edge

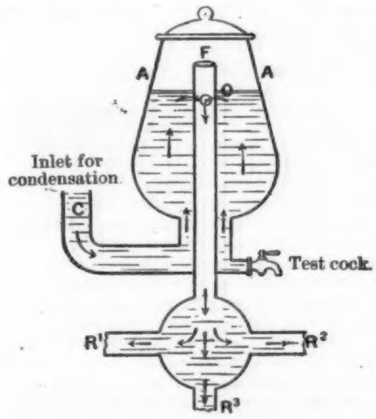


Fig. 32.—SAVALLE TEST GAGE.

to the second and so on throughout the series, while the vapor distilled from each plate rises through the perforations of the plates above and the thin sheet of liquid that covers them. The English Coffey and the German Siemens apparatus are constructed on the same principle. Sorel's apparatus has a horizontal cylinder which enables it to be installed in a farm building or other low structure. The intimate contact of the vapor with the mash is effected, not by bubbling, but by rotating disks (Fig. 29). Guillaume employs an inclined tower containing plates which force

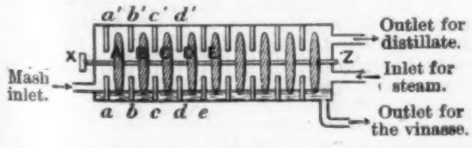


Fig. 29.—SECTION OF SOREL DISTILLING CYLINDER.

the ascending vapors to bubble through the slowly descending wash (Fig. 30).

The average consumption of coal by the types of apparatus above described is 4 or 5 pounds for each 100 pints of wash containing 9 or 10 per cent of alcohol. The use of steam for heating causes the volume of the "vinasse" to exceed that of the mash by 20 per cent. The "vinasse" obtained from beets and molasses contains salts valuable as fertilizers, which are obtained from it by evaporation. The dilution by the steam is, therefore, an inconvenience to avoid which some constructors add a tubular boiler in which the steam required for heating is obtained from the "vinasse" itself.

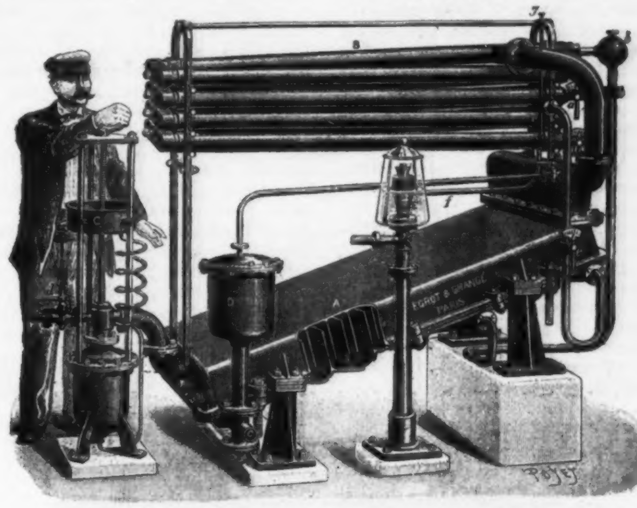


Fig. 30.—GUILLAUME DISTILLING APPARATUS.

A, Distilling tower; B, condenser heater; C, steam regulator; E, test gage.

Refining and Rectifying Apparatus.

The "flegmes" or crude alcohol furnished by the apparatus above described contains variable quantities of malodorous and poisonous impurities called fusel oil, potato oil, etc., which are more abundant in potato and beet spirit than in grain spirit. These impurities, produced by secondary fermentations, are composed of furfurol, nitrogenous substances, aldehydes, ethers, acids, and higher alcohols. As they cannot be entirely

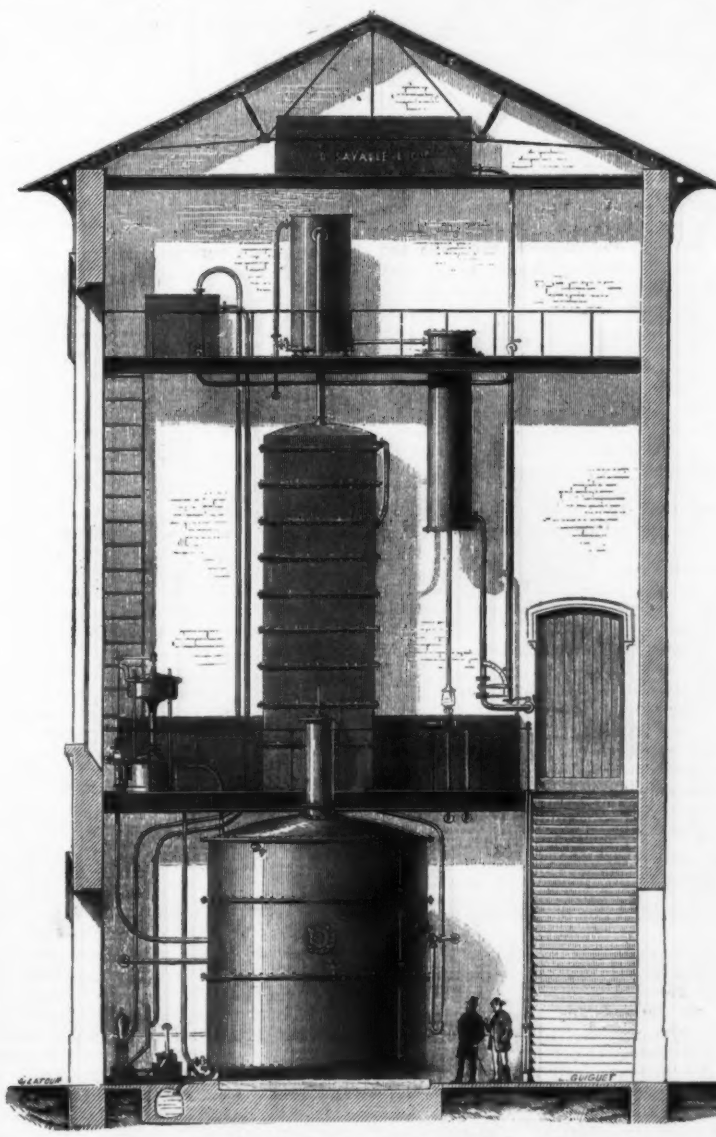


Fig. 31.—SAVALLE RECTIFYING APPARATUS.

removed by re-distillation or rectification, the crude spirit is first refined, or purified, by physical or chemical processes which partially remove them or convert them into other substances.

The physical methods include filtration through wood charcoal, bone black, or coke, agitation with olive oil, soap, paraffine, and other hydrocarbons, refrigeration, and electrolysis. The chemical methods include oxidation with oxygen, ozone, permanganates, peroxides, chromic acid, etc.; neutralization with soda, ammonia, alkaline carbonates, aluminate of barium, ethylate of sodium, metals having affinity for sulphur, etc.

For filtration, charcoal obtained from linden wood by heating it in closed vessels is preferred. The charcoal is coarsely ground and freed from dust by sifting. Two or three pounds are used for 100 pints of spirit. The charcoal is placed in a battery of 6 or 8 iron cylinders, 16 feet high and 2 or 3 feet in diameter, and the spirit flows through the entire series. When the charcoal in one cylinder is choked with impurities, that cylinder is cut out of the series, steamed and filled with fresh charcoal, the foul charcoal being re-calcined for further use. The shrinkage due to filtration amounts to 2 or 2½ per cent.

The hydrocarbon method, invented by the American, Parsons, in 1869, has been perfected by Bang and Bowick. In Bowick's process the spirit is emulsified with a heavy hydrocarbon (boiling at 570 deg. F.) and the mixture is passed through a filter saturated either with a hydrocarbon (which stops the alcohol) or with dilute spirit (which stops the hydrocarbons). *Similia similibus filtrantur!*

Of other methods we mention particularly only the Naudin electrolytic process which has been employed for twenty years in a distillery near Rouen.

The purified spirit is next subjected to rectification, or fractional distillation, by which it is further purified and separated into products varying in boiling point and alcoholic strength. One of these products called "extra fine" or "heart" spirit is nearly pure ethyl alcohol.

Savalle's rectifying apparatus, the best known in France, fills a four-story building (Fig. 31). On the ground floor the spirit is heated in a huge boiler by a coil of steam pipe, and the vapors rise to the rectifying tower in the story above. This tower contains eight horizontal copper plates perforated with a great number of holes about 1/6 inch in diameter. The alcoholic vapor condenses more or less on each plate where a thin layer of the resultant liquid is formed and prevented from falling through the small perforations by the pressure of the ascending vapor. Consequently, as in the distilling tower, the vapor is forced to bubble through successive layers of liquid, taking up additional alcohol from each and parting with water and other impurities. The depth of each liquid layer is limited by overflow pipes which drain off the excess to the plate below.

The vapor, strong in alcohol, which escapes from the top of the tower goes first to the auxiliary condenser in the story above, where two-thirds of it is condensed and returned to the boiler. The last and strongest third passes to the main condenser, to the right of the tower, where it is condensed into strong spirit, which, after passing a test gage, is distributed by pipes to the tanks for the various grades. The cold water supplied by the reservoir above flows successively through the auxiliary and the main condenser. The steam regulator, explained in connection with Savalle's distilling apparatus, is shown at the left of the rectifying tower.

The operation of rectification is delicate and requires constant attention. The spirit is first neutralized with chalk or lime and diluted with water to an alcoholic strength of 35 or 40 per cent. The product varies in quality from the beginning to the end of the operation and may be divided, roughly, into 7 parts, as follows:

"Heads"			"Heart" or	"Tails"		
poor	medium	good	extra fine	good	medium	poor
1	2	3	4	5	6	7

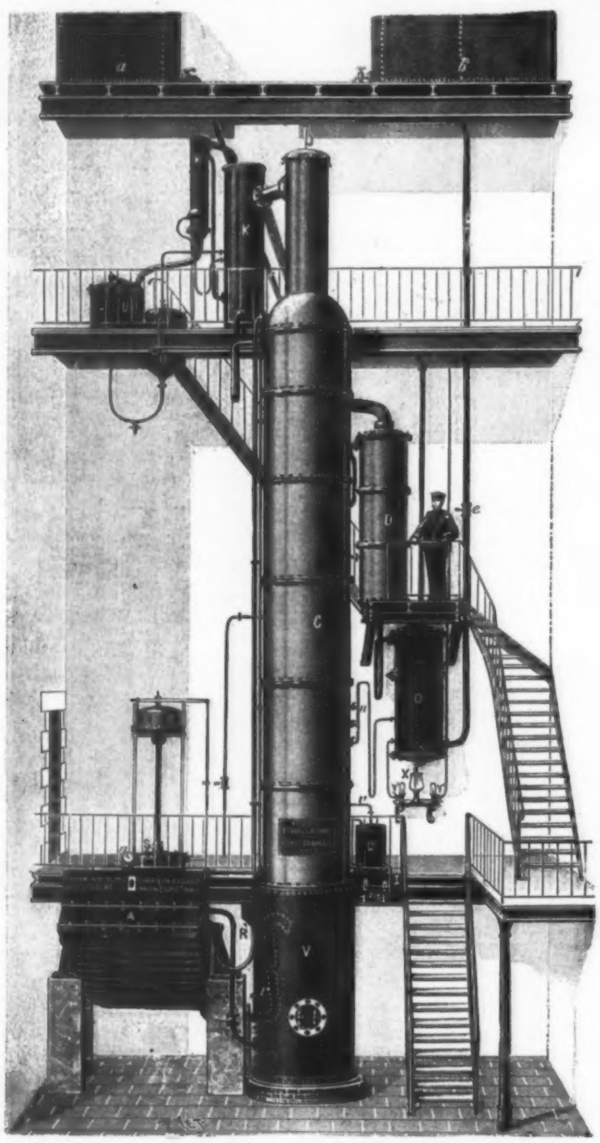


Fig. 33.—GUILLAUME APPARATUS FOR SIMULTANEOUS DISTILLATION AND RECTIFICATION.

A, Inclined distilling tower; C, rectifying tower; D, second rectifying tower; I, condenser heater; K, condenser for "heads"; K', condenser for gases; O, condenser for "good" alcohol; Q, condenser for "oils" or "tails"; S, steam regulator; X Y Y Y, test gages.

The poor grades (1 and 7) obtained at the beginning and end of the process are used in making denatured alcohol, varnish, etc., the medium (2 and 6) are redistilled, the good and extra fine (3, 4 and 5) are sold as alcohol. The test gage by which the quality and quantity of rectified spirit produced at every stage of the process are estimated is illustrated in Fig. 32. The rectified spirit from the main condenser, entering at *C*, rises into the glass jar *A*, whence it flows into the perforated tube *F* and down this tube to a small reservoir with three outlets, R^1 R^2 R^3. From these outlets pipes provided with cocks lead to the tanks for good, medium and poor spirit, and the liquid is directed to the proper tank by opening the corresponding cock and closing the others. The perforations, *O*, of the efflux tube, *F*, are of known diameter and the tube is provided with a scale which indicates the height of the liquid and hence the velocity of flow. About 64 per cent of the product is classed as "extra fine," and 20 per cent as good. The liquid which remains in the boiler contains essential oils which are used in certain industries.

Barbet's rectifier works continuously and produces "heads," "hearts" and "tails" simultaneously. This object could be effected by employing a very high tower and drawing off the "heads" from the top, the "hearts" from the middle and the "tails" from the bottom. Instead of this arrangement, two shorter towers are used. In the first or refining tower the crude spirit (not refined, but diluted to 35 to 40 per cent) is freed of the "heads," or most volatile portion, containing ethers and aldehydes. The purified spirit then passes to the rectifying tower proper which separates the "heart" from the "tails." Each of the three grades passes through a separate condenser and test gage to the respective storage tanks. It is claimed that this apparatus is very economical of fuel and reduces to a minimum the dead loss of spirit which, in the usual process, averages about 3 per cent, but its adversaries assert that it does not yield as fine "heart" alcohol as the discontinuous process.

Guillaume's apparatus (Fig. 33) is an example of a type that has recently come into use for the simultaneous distillation and rectification of wines and other thin worts. The liquid flows through the inclined distilling column, *A*, from top to bottom. From the top of this column vaporized spirit containing 40 or 50 per cent of alcohol passes to the high rectifying tower *C*, from the bottom of which the heavy "tails" or "oils" flow continuously through the test gage *Q*, while the vapor, being water by condensation as it rises, rapidly attains an alcoholic strength of 92 to 94 per cent. At the level which corresponds to this concentration the last remnant of the "tails" is drawn off through the three cocks, *u*. The "heads" are condensed in *K* at the top of the tower and the "good" spirit, after undergoing a second rectification in the small tower *D*, is finally condensed in *O*. This apparatus produces 75 to 80 per cent of "good" spirit, 10 to 15 per cent of "medium" spirits, 5 per cent of "heads," and 5 per cent of "tails" or "oils." By subjecting the medium grades to a second treatment the percentage of good spirit may be increased to 96, all the important impurities being concentrated in the remaining 4 per cent.

Brandy, rum, whisky, etc., owe their distinctive flavors to impurities. They are distilled in simple apparatus, with few or no plates, and are not rectified. The heat is furnished by steam or direct firing, and the economical device of the condenser-heater is generally employed.

The by-products of the distillery, including spent mash, "vinasse," and the carbonic acid, glycerine, and other substances produced in fermentation, are utilized as agricultural fertilizers, food for cattle, and in various industries.

Theoretically, about 64 pints of absolute alcohol (containing no water) should be furnished by 100 pounds of glucose, 68 pints by 100 pounds of cane sugar, and 72 pints by 100 pounds of starch. In practice this yield is diminished by various circumstances. About 5 per cent of the fermentable matter escapes fermentation, a second portion undergoes non-alcoholic fermentation and a third portion is consumed in the growth of the yeast. Again, part of the alcohol produced is oxidized by the yeast and another part is lost by evaporation. Consequently the quantity of alcohol obtained in practice is only 75 or 80 per cent of the theoretical yield of the *pure* sugar and starch contained in the raw material. The following table gives the practical yield, in pints of absolute alcohol, of 100 pounds of various materials:

Potato starch	34 to 40
Rice	35 to 37
Maize	28 to 31
Buckwheat	24 to 27
Soft wheat	27 to 29
Millet	25 to 26
Hard wheat	24 to 26
Rye	24 to 27
Barley	21 to 25
Oats	19 to 22
Potatoes (containing 70 p. c. water)	5 to 7
Beets (containing 80 p. c. water)	4 to 5
Molasses	23 to 25
Crude sugar	36 to 45
Dry glucose	34 to 41
Cellulose (sawdust)	7 to 10

WOOD PRESERVATION.

The increasing necessity for adopting some method of preserving wood is emphasized here by Bohumil Shimek. The rapid exhaustion of our forests is making this matter imperative, and although something may be done by proper cutting and seasoning, special treatment of the wood prolongs its life considerably. Whether special methods of preservation are employed or not, the wood should be well seasoned. To this end, if kiln-drying is impossible, the wood should be cut in the fall in order that it may have a longer time to dry slowly in the colder part of the year. If kiln-drying is practised, the wood may be cut at any season of the year. There is some advantage in using wood which has been rafted, or allowed to remain in water for some time, as this treatment dissolves out certain of the soluble organic materials. As a result, fungi find less available food material. The same result is secured by first steaming the wood. For railway ties, the steaming may be done in the open air without shelter. They should be piled in a place well drained and exposed to winds rather than the sun, and not more than two ties should come in contact with the ground. In piling, ample space should be left between the ties for ventilation. Hewn ties have smoother surfaces than sawn ties, and are, therefore, better. Charring and coating with paint or tar have some merit. The latter methods are effective only when they wholly exclude air. They are scarcely to be considered as methods of drying ties. The various preserving materials now used are given, and this is followed by a description of the methods and apparatus employed at the Alamogordo (New Mexico) Timber Preserving Plant. The plant is located in a territory in which practically only coniferous wood is available. The method employed is the Wellhouse zinc-tannin process, but the plant is also used for simple Burnettizing, in which only zinc chloride is used. The impregnating fluids are stored in large tanks from which they are drawn and to which they are returned by means of pumps. There are two retorts, each 106 feet long, having a capacity of 546 eight-foot six by eight-inch ties. The ties are placed on steel cars and run into the retort, in which they are steamed under pressure of twenty pounds for four or five hours. A vacuum of twenty-two inches is then created, and a four per cent solution of zinc chloride is introduced under 100 pounds pressure for four hours. The amount of pure chloride consumed per cubic foot of wood varies for the material here employed from 0.29 to 0.33 pound. The chloride is then followed by tannin, of which a

sixth of a pound per cubic foot is employed for about one and one-half hours, and this in turn is followed by a one-half per cent solution of glue. The entire run consumes from eleven to eleven and one-half hours. If green wood be used, the time required for steaming and impregnation must be extended from one to one and one-half hours each. The process darkens the ties somewhat. After the treatment, the ties should again be thoroughly seasoned for several months before they are used.—Abstracted by the Electrical Review (N. Y.) from the Transit, State University of Iowa, Iowa City.

[Concluded from Supplement No. 1604, page 25708.]

INDUSTRIAL APPLICATIONS OF GYPSUM.—II.*

By Robert Grimshaw.

Having considered at length the various uses of stucco gypsum, or that calcined at comparatively low temperature, the next topic is that of the hydraulic variety, burned at a red heat, containing in the calcined condition much less water than the other, but also having the property of absorbing water in setting, in much less degree; also setting much more slowly and much more firmly. Another peculiarity of the hydraulic variety is that it does not expand at the moment of setting—a feature which makes it much less valuable for making casts, but gives it increased value for the preparation of large surfaces where shrinking cracks and other signs of settlement and interior perturbations are inadmissible. The compressive strength of a well laid-up mass of hydraulic gypsum is given by Seger and Cramer as 250 kilogrammes per square centimeter, which corresponds to about 1.6 gross tons per square foot.

The use of hydraulic gypsum as mortar dates back to the earliest builders. The Harz and other parts of northwest Germany are full of sturdy structures, centuries old, which were put up with hydraulic gypsum mortar, which has the advantages of clinging more firmly to the stones or bricks than lime does, and of hardening more rapidly, besides enabling all kinds of building operations to be carried on through the winter. The use of plaster between colored tiles is quite general, by reason of the greater neatness of the joints. Further, the plaster can be more readily colored to match the tiles, if this be desired, than a lime mortar.

These remarks apply only to the hydraulic variety.

The next application of hydraulic gypsum to which we may turn our attention is for floors. Here it offers a smooth water-tight surface that withstands severe usage; only in laying it care must be taken not to lay it on wood, or dry stamped clay or bricks, as these materials absorb the water from the gypsum plaster and ruin the floor. The gypsum must not be laid in direct contact with cement beton, either; it is necessary here to provide an intermediate layer of sharp sand or well-screened coal ashes, which after being well stamped down and thoroughly sprinkled with water, will be ready to receive the plaster.

In mixing the gypsum plaster the material is to be thrown into the water until it appears above the surface; then all is to be carefully worked with shovel, etc., but only after the gypsum has absorbed all the water that it can. As a general rule it can be said that one measure of water will take three of gypsum and yield two and a half measures of mortar.

There is no material which can be added to the gypsum to increase its strength. Where it is not to be directly trod upon, as where it is to be covered with linoleum, for office floors, etc., it will do to mix therewith one-third coke slag or some similar neutral substance.

After laying, the floor is to be let harden until the finger makes little or no impression therein; then it is to be beaten down with a leveling board until it loses nearly a quarter of its thickness. This will bring out any excess of water. No water must be added during this condensing process; it would only retard the hardening, and lessen the firmness of the hardened mass. It is, however, often advantageous to sprinkle the floor from time to time after it has been fully flatted down. In from one to two weeks the floor will be ready to be walked upon. If linoleum is to be laid thereon, the cement must be bone dry.

One advantage of the use of gypsum as wall covering or floor surfacing is that being chemically neutral, it permits the use of various coloring materials which would be altered or indeed entirely bleached out by lime. Any one who has tried to make blue lime-wash will appreciate this property.

A very neat finish may be imparted to the plaster surface by a coat of hot linseed oil followed by a well-rubbed-in solution of beeswax in turpentine or one of paraffin wax in benzine.

Among the advantages of the hydraulic gypsum floor are, as enumerated by Seger and Cramer in their admirable pamphlet prepared for the German Association of Plaster Manufacturers, cheapness, durability, fireproofness—if there be such a word in the Standard Dictionary—non-conductivity to heat, freedom from joints or cracks, protection against mice and other household vermin. For vestibules and corridors, verandas, store-rooms, kitchens, and granaries, as good results can be got with gypsum as by the use of tiles and other coverings, and such a floor is warm and comfortable under foot. For attic floors, there is the advantage of protecting the roof from fire originating in the stories below; and the same applies to fodder and hay lofts. Covered with linoleum, there is no floor more agreeable for living-rooms and offices. Here there is the advantage that there are no joints to spring and cause cutting of the linoleum, as in the case of boards. As against cement for the same purpose there is the advantage that there is no rotting of the vegetable fibers in the linoleum by reason of the moisture that gradually exudes from the cement long after it is apparently dry.

To revert to the use of hydraulic gypsum as a wall surface—there is not to be lost sight of the capability of being tinted as desired with mineral colors. Further, if the plaster surface be well treated with a solution of paraffin wax in benzine or petroleum, such walls may be washed down without affecting their surface. For walls that are to be papered, the plaster affords more hold to the paper than the ordinary lime coating.

For outside wall surfaces, gypsum offers the advantages against lime and Portland cement of being harder and less affected by the weather; and this quality may be greatly heightened by treatment with linseed oil or paraffin wax.

When it comes to making building stone out of gypsum, the reader will probably be rather incredulous; but while blocks of stucco plaster are light and suitable for partition walls, those with, or of, hydraulic gypsum are heavy and hard, and perfectly suitable for outside walls that have weight to bear—to say nothing of filling for buildings constructed with steel frames that carry the roof and floors. In the southern Harz district where bricks were both dear and bad, a commencement was made to replace the last with hydraulic gypsum blocks of normal brick size—in Germany the size of bricks is fixed by law. The success attending this experiment led to making so-called "ashlars" of the same material, and also cornices and other architectural members. Walls of gypsum blocks with a wash of linseed oil or solution of paraffin wax in petroleum or benzine have proven themselves better than those of ordinary clay brick masonry, sandstone, or limestone, and only surpassed by granite and hard-burned bricks (called "klinkers" in Holland and northwest Germany). The only fault that they have is one which they share with bricks, sandstone and limestone—they should be well isolated from the moisture of the ground by slate, tar or other water-proof material between them and the foundation walls. Against frost they are more resistant than either sandstone or clay brick.

From the artistic point of view such gypsum "ashlars" have the decided advantage that they may be given any desired form and size, whereas stone will not always cut to advantage; they may be given any wished-for finish at the same expense as for a plain surface, whereas tool-dressing and hammer-dressing of stone is expensive, especially in America; and they may be colored any tint called for, by cheap mineral substances.

* Specially prepared for the Scientific American Supplement.

CORUNDUM AND ITS USES.

As an abrasive, corundum is a material of importance in connection with a number of modern processes, and while the artificially-produced mineral is largely used at the present time, many important deposits of natural corundum are being economically mined in different parts of the world.

In chemical composition corundum is a compound of alumina (Al_2O_3), this base being present to the extent of from 95.5 to 98.79 per cent. Other matters present in varying degree are silica, water, and ferric oxide. It follows that these are only present in exceedingly small quantities, and the presence of silica must in no way lead to the confusion of corundum with carborundum, which latter mineral is, in fact, a true silicide of carbon (SiC), and which was only named carborundum by being mistaken for a form of alumina.

Corundum is found in a variety of forms of different quality and value. At one end of the scale are the gems ruby and sapphire, and at the other a mixture of corundum and magnetite commonly called emery. As a gem, the value of corundum varies according to color, index of refraction, hardness, luster, etc.; but with such matters we, of course, do not deal. Gems, however, are of practical value to makers of scientific instruments, etc., as owing to their hardness they form excellent bearings, and are used not only by watchmakers, but also in the manufacture of electrical measuring instruments; and in this field corundum of gem quality, in the form of small rubies, sapphires, etc., is of considerable importance.

It is, however, with corundum used as an abrasive that we are more directly concerned. In hardness this mineral ranks next to the diamond, and is represented by 9, the diamond's figure being 10. Hardness alone is, of course, no final recommendation, for, though it may be hard, a crystal on being broken may become rounded, when the sharp edges necessary for abrasive purposes would be wanting. It is one of the peculiarities of corundum of good quality, and which is necessarily free from decomposition or alteration, that it breaks and wears in such a manner as always to present sharp cutting edges. The gem quality being transparent, ordinary corundum is as a rule no more than translucent, and often even opaque, and is of a variety of colors, including pink, red, green, blue, yellow, and white. It is found in contact with rocks of both igneous and metamorphic formation, and in one form or other it is found scattered all over the world. Gems come from Asia, America, and Australia; corundum of abrasive quality from North America, India, etc.; and emery from North America, Greece, Turkey.

The mineral, as we learn from a most interesting bulletin on the subject, written by Mr. J. H. Pratt, and published by the United States Geological Survey, is not by any means worth working in all the districts in which it has been found. Indeed, having in view the fact that it is now manufactured from bauxite in the electric furnace, its economic mining can only be carried on under favorable conditions. Such conditions prevail, for instance, in Canada, in the Ontario province, where corundum of good quality has been mined, and mills, some of them of a capacity of 15 tons daily, are at work. In this district the corundum occurs in syenite as a primary constituent of the rock. This rock runs in dykes through the gneiss, and the seams vary in width from a few inches to several feet. The chief deposits occur in Peterborough, Lanark, and Hastings, etc. In the United States corundum occurs in North Carolina and Georgia in peridotite, and also in greater quantities at the line of contact of peridotite and gneiss, or gneiss and dunite. These deposits also are not always of a nature to be economically mined, but work is going on in Mason County at the Corundum Hill Mine, and in Clay and Transylvania Counties in North Carolina, and at Laurel Creek in Georgia. Corundum of emery form—i. e., fine, and mixed with magnetite—is found in quantities sufficient to be worked economically in the Chester district, Massachusetts, and is exported in quantities from the Island of Naxos, Greece.

The treatment of the ore, after mining, is somewhat similar in process to the sluicing of gold quartz, but the method is modified according to the nature of the mine product and the rock formation whence it is drawn. The ore is crushed and sieved first, and then sluiced. On account of its great specific gravity, the ore is readily separated in this way from the other material, which is carried away by the stream. If the ore be one which contains large quantities of impurities, it is next transferred to a scouring machine, which is, in form, similar to a worm-conveyor. Finally, it is passed through a rolling process in a "muller," a circular power rolling mill with heavy wooden rollers. The product is then washed, spread on a sloping platform, and allowed to drain all night. It is then dried in one of two ways—either by being passed through an inclined revolving cylinder or drum, in which there are coils of heated pipes, on which the corundum falls when raised by the rotation of the drum, or by being conveyed up to a height of some 20 feet or 30 feet, and dropped down the flue of a furnace onto an inclined iron plate, down which it slides into an iron box. At the present time corundum is chiefly used in the manufacture of grinding wheels. As grinding has taken the place of much lathe work, wheels of first-class quality are necessary. These wheels are of three types—namely, chemical, vitrified, or cement wheels, so named from the manner in which they have been manufactured. The chemical wheel is considered the safest and most satisfactory for wheels of large diameter, but vitrified wheels are most generally used for the more moderate sizes. In these great care is necessary in the selection both of the quality of the corundum itself and of the bond, for if any foreign material introduced or present in the ore contains water of composition, the wheel is liable to burst during vitrification. Wheels are manufactured by this process in the following manner: The corundum and bond are thoroughly mixed and poured into paper molds and set aside to dry. When hard enough to be handled without hurt, they are trimmed and dressed on a potter's wheel. They are then dried more thoroughly. When completely dry they are built up inside conical kilns 12 feet to 20 feet in height, and from 10 feet to 18 feet in diameter. The kiln is sealed and the fire started. At first the temperature is carefully regulated, so that the moisture included in the parts, and also the water of crystallization, is slowly driven off. When this is complete the temperature is raised to some 3,000 deg. F., and the fire maintained at this heat for several days. The fusion of the clay and bond being complete, the kilns are allowed to cool slowly. The wheels are then withdrawn, taken to a lathe and trued up, bushed, balanced, and finished.

In the chemical wheel silicate of soda is mixed with the corundum or emery. This is molded and tamped, and then subjected to "oven" heat for 24 hours and finished in the manner described above. In the cement wheel shellac or other substances are used for bonding.—Engineering.

Measurement of Resistance.—W. Jaeger discusses the four chief methods of measuring resistances with the needle galvanometer, and points out the cases in which they can be used to the greatest advantage. In Thomson's method, the resistance to be measured A should be nearly equal to the standard B. The ratio of the bridge resistance a to A should be very small. The galvanometer resistance g should be $A/2$. The sensitiveness is then $E/2\sqrt{2}$. In Wheatstone's bridge arrangement, the most favorable conditions are given by $a = A$, $B/A =$ infinite, $g = 2A$. The sensitiveness is then the same as in Thomson's method. The differential method is the most sensitive when the conditions are favorable. These conditions are $b = A$, $aB/A^2 = 1$, $a/A = 0$, $B/A =$ infinite, and $g = A$. The sensitiveness is then $\frac{1}{2} E$. The compensation method is the least sensitive under the most favorable conditions, which prescribe $b = a = A$, $a/A = B/A = 1$, and $g = A$. The sensitiveness is $\frac{1}{4} E$, E being the E.M.F. used. The differential method can only be employed with large resistances. If the resistance A and b can be changed simultaneously by the same amount, a sensitiveness $= E$ may be attained. With a movable coil galvanometer of half the sensitiveness of a needle galvanometer, the same delicacy of measurement of resistances can be attained.—W. Jaeger, Zeitschrift für Instrumentenkunde, March, 1906.

Correspondence.

HOW THE SEA AFFECTS THE CLIMATE.

To the Editor of the SCIENTIFIC AMERICAN:

In your issue of August 25, in a most interesting article on "The Effect of the Sea upon Climate," is the following paragraph:

"It requires only a rearrangement of the direction of the main Atlantic currents wholly to change the climate of western Europe. Such an arrangement would be effected by the submergence of the Isthmus of Panama and adjacent country, allowing the equatorial current to pass into the Pacific."

The following facts will disprove this supposition: The equatorial currents both in the Pacific and the Atlantic oceans are caused by the rotation of the earth, and move from west to east, modifying the climates of every country on the western coasts of all the continents. The Pacific Ocean at Panama is several feet higher than the Atlantic Ocean because of the pressure of the whole Pacific Ocean against the barrier offered by the continents of America. If then the Isthmus of Panama were to disappear, the Pacific current would simply pass uninterrupted, and with a mighty mass of water, through the break, following after and increasing the speed and volume of the Gulf Stream.

This is the greatest reason for a tide-level canal at Panama, as its current would be constant, and would keep the canal free. A recent cross section of the canal, showing the work already completed on the site of that future world-desired opening for commerce, shows that enough material has been moved by the French company, and transported up and down hill, to have finished the canal if they had followed the plan of tunneling at sea level from both sides. The writer has never seen this plan discussed, but it certainly is easier to undermine a mountain than to carry it away pi^ce by piece up and down hill. By this plan lighters could move the material by the canal itself, and deposit it where it was needed.

It is certain that no atom of the Atlantic Ocean would ever enter the Pacific by the Panama route until the earth changes its direction of rotation.

E. M. SOUVIELLE.

Jacksonville, Fla., August 27, 1906.

THE FLIGHT AND SOARING OF BIRDS.

To the Editor of the SCIENTIFIC AMERICAN:

I have read with interest an article in the SCIENTIFIC AMERICAN SUPPLEMENT of May 5 by Mr. Twining on the flight and soaring of birds explained on mechanical principles. I have no doubt his conclusions are correct, if we grant him his first premises. But in my opinion his assumption that the wing of a bird should be treated as a plane is quite incorrect. This initial mistake has entirely vitiated all his conclusions. If you examine critically the wing of any large bird you will see that the shape of the wing is anything but a plane surface. The simplest way of treating these questions is to take as an analogy something of which we have a practical working knowledge. Now the nearest analogous thing to a bird's wing is the sail of a boat or more properly a cutter yacht. The only difference is that the sail is vertical while the wing is horizontal. It is well known to yachtsmen that a boat will sail when the wind is right abeam, and in fact I believe good boats will sail well even when the wind is forward of the beam. Such a thing would be practically impossible if the sail were a rigid plane surface as Mr. Twining would have us treat the wing of the bird. The whole secret of the forward movement of the yacht, and similarly of the bird, lies in the fact that the sail and the wing have a curved surface, in fact what yachtsmen call the belly of the sail. As is well known, the resultant acts at right angles or normally to the surface, hence the normal to the sail or wing near the mast or wing bone, as the case may be, acts in the direction in which the bird or boat is moving. Whether the wing is beating the air as in flying or is acted upon by the wind as in soaring, the resultant always acts forward and enables the bird to advance. In soaring the whole process is exactly the same as in the case of a boat sailing with the beam-wind. In the case of the boat the gusts of wind strike the sail at right angles to the course, but the curved belly of the sail causes the resulting pressure to act forward and the boat advances. In the same way the wind meets the bird, but, as is well known, owing to the resistance of the earth the wind is deflected in an upward direction, and the rising wind catching the bird on the under side the resultant pressure is turned forward by the curved belly of the wing and the bird is carried forward. The wing is exactly like a sail laid horizontally where the wing bone and muscle correspond to the mast and the loose ends of the feathers to the after edge of the sail. The wind, though apparently blowing parallel to the earth's surface, in reality has always an upward tendency, owing, probably, to friction whereby the lower strata do not travel so fast as the upper. In the case of the unwary traveler whose hat is carried off at a street corner by a gust of wind the hat is always lifted up and then away. When a dust storm or tornado advances clouds of dust are whirled high up in the air, showing the upward tendency of the air currents. It is this, combined with the peculiar curved shape of the wing, that enables a bird to soar steadily in the teeth of a gale, as I have often watched them do for hours at a time. I believe that it is in following the guidance of nature in these directions that success in artificial flight and aeroplanes will be attained. Moreover, I am not sure that by a judicious arrangement of horizontal sails we shall not be able to sail a boat in the teeth of a gale instead of having to tack backward and forward to gain a very little way.

Kashmir, India, June 7, 1906. M. FIELD.

HOW TO IMPROVE TELEPHONY—MECHANICAL AND ELECTRICAL PHENOMENA IN TELEPHONIC TRANSMISSION.

By the English Correspondent of SCIENTIFIC AMERICAN.

AT the recent annual soiree of the British Royal Society, the interesting and ingenious apparatus devised by Mr. W. Duddell for demonstrating the mechanical and electrical phenomena which occur in the transmission of speech through telephones was exhibited. By means of curves projected on a screen it is possible

Vowel *ā* in *Ma.*

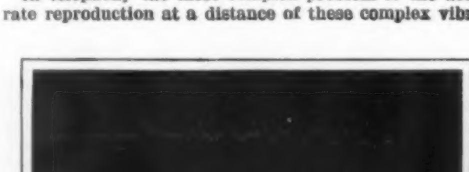
to discern with this instrument the simultaneous movement or oscillations of the microphone transmitter diaphragm, the current flowing into the line, the current received at the distant point of the wire, and the movement of the receiver diaphragm during the transmission of the words or sounds. There are five of these curves—four without the zero line—and these are shown one above the other, and the differences between the transmitted and received sounds, together with the variations produced by the self-induction of the line and other phenomena, are very marked. It is also possible to observe the characteristic shapes of the curves corresponding to the various vowel sounds, and their dependence upon the tone or pitch at which they are sung. The current movements are ascertained by means of a double oscillograph, while simple contact devices and little mirrors contained in a box about twelve inches square enable the reproduction of the diaphragm movements to be observed. A direct current is utilized to give the time ordinates, and one lantern for the various mirrors.

That many improvements in telephony remain to be

Vowel *ē* in *Me.*

effected is a well-known fact, and the main directions in which this efficiency is required is in connection with the loudness and articulation or clearness of the transmitted speech and the distance over which it can be transmitted. The sensation of sound, as is well known, is produced by the vibration backward and forward of the particles of the air about their position of rest, and the character of the sound depends on the quickness and the form of the vibrations. Thus, in the case of a musical note, the air particles vibrate in a perfectly regular manner, and the number of complete vibrations in a second, or the frequency, determines the pitch; and the amplitude, or distance the air particle moves from its position of rest, determines the loudness of the note. In speech, however, the vibrations are very complex, and in order to form any clear mental idea of their character, it is necessary to represent the movements as curves, which are described by Mr. Duddell in connection with his apparatus as sound patterns.

In telephony the most complex problem is the accurate reproduction at a distance of these complex vibra-



K and first of *e* in *Key.*

tions of the air; the more nearly the movements at the receiving station correspond to those at the transmitting point, the better is the quality of the telephony. If the movements at the former point are similar in pattern but of less amplitude than those at the transmitting station, then an attenuation of sound results; on the other hand, should the sound pattern at the receiving point be distorted, then loss in articulation results. Fortunately, however, the ear possesses a wonderful faculty and power in recognizing a sound pattern even when it is considerably distorted, since otherwise in transmitting a sound pattern, telephony over anything like the distance which it is at present possible to converse would be impracticable.

In regard to the action that takes place between the original air movements and their final reproduction at a distance, the former are first converted into movements of a diaphragm, which movements are again mechanically transmitted to the carbon grains in the microphone, thereby varying its electrical resistance. This feature of the microphone causes the current through it and the connected transformer to vary, and so induces varying currents in the secondary of the transformer. This secondary is connected to the line, so that the currents are conveyed to the receiver at the distant place. The currents are here transformed into a varying magnetic field, which acts on a diaphragm, causes it to vibrate, and thus set the air around it in motion. In all this long train of transmissions and transformations the character of the original sound pattern has to be preserved sufficiently well

Vowel *o* in *Ho!*

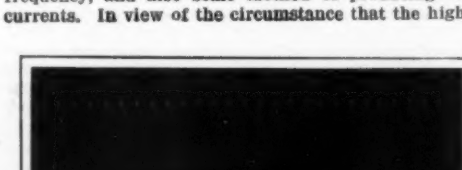
to enable the ear at the distant end to recognize it in its final form. When it is remembered that at each one of these successive steps distortion and loss of energy must take place, the difficulties in the way of telephony may be grasped.

In view of the high standard of excellence which telephony has attained, the question arises as to how it can be improved. There are losses and distortions, but what are their extent and how can they be avoided? The only solution of the problem, as Mr. Duddell emphasized before a recent meeting of the British Royal Institution where he described these phenomena and his apparatus, is by systematic, accurate measurement and experiments. On this point the inventor drew attention to the little quantitative data available in the literature relating to telephony as compared with other branches of engineering, which fact he attributes to the difficulties of making the measurements required and the deficiency of suitable apparatus for accomplishing the purpose.

According to the recent investigations of Prof. P. E. Shaw with his sensitive micrometer, the amplitude of

Complex form of *ōō* in *Coo.*

the movement of a telephone diaphragm is extremely small. The movement that takes place in the case of a comfortably loud impulsive sound is only one twenty-thousandth part of a millimeter, and that something less than one-fiftieth of this is just audible. The extremely small quantities with which one has to deal in telephony investigation can thus be realized. The diaphragm has a frequency of vibration of its own, which in ordinary receivers may be about 500 complete vibrations per second. Owing to resonance, it will therefore tend to reinforce notes having the same frequency as itself, that is about the octave above middle C. This tends to the very unpleasant attenuating of certain no.es when music is transmitted telephonically. It appears that this might be overcome by applying some form of damping to the diaphragm, or by making its frequency of vibration very much higher. In order to test the electrical parts of the apparatus, it is necessary to devise some means of measuring small alternating currents of fairly high frequency, and also some method of producing these currents. In view of the circumstance that the highest



Simple form of *ŏŏ* in *Coo.*

frequency does not exceed about 2,000 periods per second, and that alternators have been constructed having much higher frequencies, it would seem comparatively easy to construct an alternator to produce these currents, but the great difficulty is to obtain a machine which will give a strictly sinusoidal current under all conditions, to enable the experimental results to be easily compared with theory. Practically, all the instruments at present applied to the measurement of high-frequency currents are thermal instruments, but these methods only give the root-mean-squared or heating value of the current.

In order to investigate the distortion in the sound pattern when translated into a varying electric current as it flows along the line and through the differ-

ent sections of the apparatus, it is necessary to record the current at every instant, and also at two or more points in the circuit. This can be easily accomplished by means of such an oscillograph as Mr. Duddell has designed, and with which the records of the sound patterns accompanying this article were obtained. To obtain a more complete insight into the distortion produced by different parts of the apparatus and line, by gearing small mirrors to both the transmitter and receiver diaphragms, records can be simultaneously obtained of the movement of the transmitter diaphragm, the current flowing into the line or cable, the current flowing out of the line, and the movement of the receiver diaphragm. With the apparatus that he has devised Mr. Duddell has been enabled to carry out a large number of investigations concerning the phenomena of telephony with complete success, and has considerably added to our knowledge of the subject.

TWO INSTRUMENTS FOR THE COMPOSITION OF SIMULTANEOUS MOVEMENTS.

By DR. ALFRED GRADENWITZ.

LIKE the fundamental theorem of geometry, the Euclid axiom, the proposition of the parallelogram of forces is known to be susceptible of no rigorous scientific demonstration. The actual experimental proof of this theorem, which should therefore seem to be all the more important, is however readily obtained by means of the "universal parallelograph," designed by Prof. P. Salcher, of Fiume.

This apparatus consists of four bars of equal length and eight bars of half this length, all suitably jointed, so that the four angles 1, 2, 4, 3 (Fig. 1) always determine a parallelogram, irrespective of any alteration in the shape of the whole figure.

While this apparatus may be used for demonstrating any phenomena depending on the theorem of the parallelogram of forces, its most interesting applications are for illustrating the laws of oblique projection and the composition of circle movements. The two instruments constructed for these special purposes on Prof. Salcher's plans by Max Kohl, at Chemnitz, Germany, are represented in Figs. 2 and 4 respectively.

FIG. 2.—PROJECTION DIAGRAPH.

The *projection diagraph* (Fig. 2) is mounted, together with its accessories, on a vertical board, the angle, 1, being fixed in such a way as not to interfere with any rotation of the bars crossing there. The angle, 2, being attached to a string, is free to slide in a vertical direction, alongside the scale, *I*, while the angle, 3, being connected to the same string, is displaced alongside the scale, *II*. To the fourth angle is fixed a recording pencil registering the resulting motion on a sheet of paper fixed to the board.

The string has one end fixed to the circumference of a spiral-shaped metal disk, the other end being attached to the circumference of a circular disk. Both disks are mounted on a common axis and are susceptible of a simultaneous rotation by means of a crank and gearing. The string is tightened by a weight. As it is unwound from the spiral disk, the edge, 2, will slide downward alongside the scale, *I*, and as it at the same time is wound up round the circular disk, the angle, 3, will move upward on the scale, *II*, and *vice versa* for an opposite rotation of the crank.

The scale, *I*, includes 10 distances, 4, 12, 20, 28, 36, 44, 52, 60, 68, 76 millimeters, corresponding to the ratio of the paths traversed by a falling body during the first ten subsequent intervals of time; while the scale, *II*, includes ten equal distances of 40 millimeters each, corresponding to the path of a uniform motion during the same intervals of time.

The ruler bearing the scale, *I*, is fixed in a vertical position, while the scale, *II*, being free to rotate round the lower end, may be adjusted to any desired angle by clamping the upper end to a wire arc fitted above the angular scale from 0 deg. to 90 deg.

The apparatus further includes another circular disk of larger dimensions to which ten radial wires are fixed at equal distances, passing along a mark during the crank motion.

After first demonstrating that on moving the crank, either of the angles, 2 or 3, separately transmits its motion without any alteration to the angle 4, when they are not attached to it, the other angle being loosened from the string, both angles are fixed to the latter, so as to transmit their motions simultaneously to the angle, 4, which thus *performs the resulting motion*, according to the theorem of the parallelogram of forces. In fact the fourth angle always moves in such a way (Fig. 3) as to determine a parallelogram with the initial position (4) and the component positions (2 and

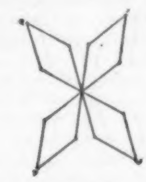


FIG. 1.

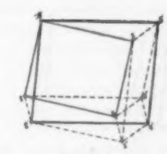


FIG. 3.

3). As the angle, 2, during the motion of the crank, drops along the scale, *I*, the free fall of a body is represented more or less slackened, the slackening being dependent on the speed of the crank, as in the Atwood machine on the additional weight. The angle, 3, sliding simultaneously upward on the scale, *II*, the other component of projection, viz., the uniform motion, is represented with a proportionate slackening, which since it is the same for both motions, will thus not exert any influence on the character of the resulting motion.

In order to simplify calculation, the distance of 40 centimeters has been chosen as the falling distance, and has been divided into ten units of time. It is readily demonstrated that the simultaneous path of uniform motion in the vertical projection should likewise be 40 centimeters, in order that the body may come back to its initial position after traversing a falling distance of 40 centimeters. The circumference of the smaller circular disk has therefore been so designed that as the angle, 2, traverses the distance of 40 millimeters in a slackened fall, the angle, 3, moves upward at the same time in a uniform motion over the same

FIG. 4.—CIRCLE MOTION DIAGRAPH.

distance. If now the ruler, *II*, be placed in a vertical position, the angle, 2, moving upward along the scale, *I*, and the angle, 3, upward along the scale, *II*, this is readily confirmed, while the speed of the resulting motion is seen to decrease to zero, in order afterward to increase up to the initial value. The resulting motion is further seen to remain the same on turning the crank in an opposite direction, the motion of the angles 2 and 3 being inverted; both on being thrown upward and on falling downward, a body would accordingly perform the same motion as in the vertical upward projection.

In order to demonstrate the laws of oblique projection, the ruler, *II*, is subsequently adjusted to various starting angles, when the corresponding parabola will in each case be recorded by the pencil, the projection distances of complementary starting angles being arrived at automatically, and any other theorems being readily demonstrated.

The other instrument referred to above is the *circle motion diagraph* (Fig. 4). This includes the same universal parallelograph as the projection apparatus and is likewise mounted on a vertical board with the angle, 1, fixed in position. Two angles, 2 and 3, are placed on fixed pulleys at any distances from the axis, while the angle, 4, receiving the recording pencil, registers the resulting motion on a sheet of paper or on a plate of smoked glass. A thin string surrounding both pulleys is fixed at its ends to a double roller, on which it is partly wound up, so that on rotating the roller by means of a crank, the string, being tightened by a weight and guided by small rollers, is unwound from one and wound up on the other roller. These will thus, according to the arrangement of the string, rotate in either the same or in opposite directions.

Now the angles 2 and 3 of the parallelogram will describe circles, their motion being transmitted to the fourth angle which accordingly performs the resulting motion. The apparatus thus allows of an exceedingly simple demonstration of the motion resulting from component circular motions.

These experiments are evidently susceptible of many variations. When fixing either of the pulleys, the component motion of the other may be represented apart; the radii may be altered, the direction of the component motions inverted and the ratio of their respective speeds varied by replacing one of the double rollers. These alterations are carried out so readily and easily that the most various cases of the composition of circle motions are represented in a few minutes' time, recording the resulting trajectories, the complicated construction of which in many cases could hardly be carried out by means of the ruler and circle.

Some examples are illustrated in Fig. 5. Curves *I* to *III* illustrate the resultant of two circular motions occurring in the same direction, the radii and angular speeds being different, while curves *IV* and *VI* represent the composition of component motions of opposite directions.

The construction of the resultants of simultaneous circular motions is important alike for science and industry. As regards the former, it is especially useful for the geometrical theory of curves, and for those parts of physics which deal with wave phenomena. An interesting case is applied for instance to the rotation of the vibration plane of polarized light in the magnetic field which may be explained as follows: If two opposite circular motions of equal radii and slightly different angular speeds be composed, the resulting motion will be found to consist of rather narrow loops, moving to the left or right through half the angle by which the one circular motion is in advance of the other. These phenomena are readily stated by means of the scales as well as by the index at the circumference of each roller.

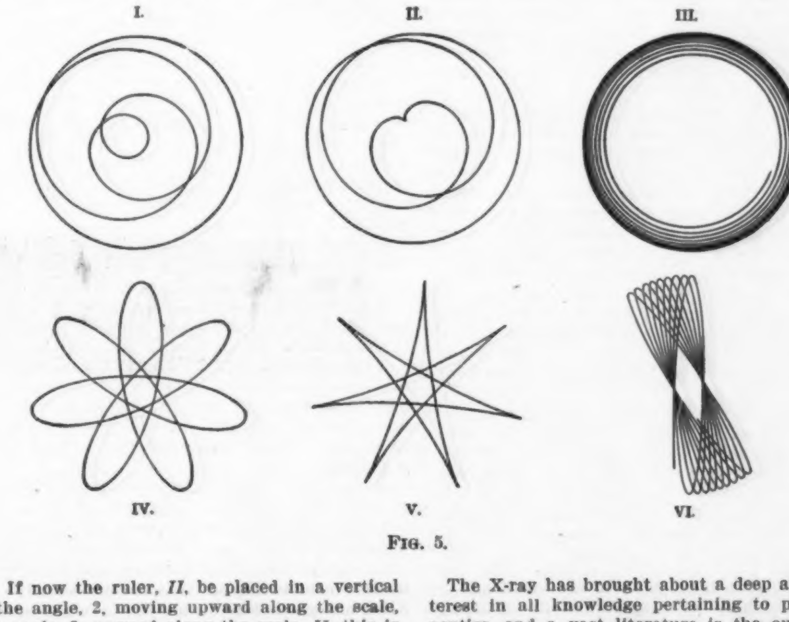


FIG. 5.

X-RAYS AND RADIO-ACTIVE SUBSTANCES AS THERAPEUTIC AGENTS.

By EMIL H. GRUBBE, B.S., M.D., Chicago, Ill.

EVERY up-to-date member of the medical profession is doubtless aware of the great therapeutic value of radiant energy, and its unprecedented success in the treatment of certain diseases.

The X-ray has brought about a deep and general interest in all knowledge pertaining to physical therapeutics, and a vast literature is the outcome of this profound and universal study. On account of its novelty, physicians at first hesitated to use the X-ray therapeutically; but now, since clinical experience and the testimony from the best professional sources have fully confirmed the claims made for it, and have es-

tablished it as a therapeutic agent of superior value, its use is rapidly supplanting many of the other older measures.

There is no doubt that the great question of modern pathology is the cause of cancer. The true pathology of this disease is unknown beyond the fact that cancer tissue is made up of cells which are either under- or over-developed. Again, there is no doubt that the great question of modern therapeutics is the cure for cancer. The remedies which have been suggested from time to time are too numerous to catalogue. A remedy, however, which has been found to produce excellent results in nearly all cases, and cures in many, is the X-ray. The results obtained with this remedy have been of so good and marked a character, that it may be considered the most valuable measure in the treatment of this disease.

Up to the time when the X-ray was first used in malignant diseases, the treatment of these conditions was attended with highly unsatisfactory results. We may say the introduction of the X-ray worked a revolution in the therapy of malignant diseases. Cases hitherto intractable have been cured in short order, and so well has this remedy maintained its reputation, that at present it may be considered a specific in many of these conditions. We believe we are warranted in stating that it is the opinion of those who have had ample opportunity to observe all the various forms of treatment applied to malignant diseases, that the X-ray treatment, when scientifically given, is unquestionably the best for the majority of cases.

The exact mode of action of X-rays upon tissue is still to a large extent a matter of speculation, and must remain so until we arrive at some definite conclusion as to the exact nature of both the X-ray and cancer.

Soon after the discovery of the therapeutic value of the X-ray, the writer began experimenting with fluorescent chemicals for the purpose of augmenting or increasing X-ray action upon the tissues of the human body. Entirely independent, and even before we read of experimental work on the part of others, our investigations were under headway. It occurred to us that in the treatment of some cases, notably external lesions, by means of the X-ray, the therapeutic effect was too temporary or not powerful enough at the real seat of the disease. In other cases, particularly internal lesions, the results were not as satisfactory as we would like, due to the fact that the X-rays had to pass through a large volume of healthy tissue before reaching the diseased parts.

It has been known for some time that under the influence of X-rays many chemicals fluoresce. It has also been known that this fluorescence of chemicals produced a similar effect upon tissue as that following X-ray exposure; consequently, since by combination we get multiplied effects, this mode of treatment would have distinct advantages over the X-ray alone. Chemicals excited to radio-activity by means of the X-ray after being placed intimately in contact with the diseased parts, either by the injection method or external application, would, if successful, possibly prove valuable in many cases where up to this time we had been considerably handicapped. There is no question that there is an enormous amount of energy stored up in these substances, and this energy is made available through the medium of X-ray action. As the result of clinical observation and experiment, we claim that by this method we can accomplish with a few exposures what could only be obtained after a great many sittings under the X-ray alone.

Although we have spent several years (nearly six) in research upon radio-active bodies, and a long series of painstaking as well as painful experiments have been made, it is not our intention to speak of all the substances known to fluoresce under X-ray activity or to detail the minutiæ of methods to be employed in the use of these agents therapeutically. We shall confine ourselves only to one particular substance, which we have investigated thoroughly. The results of these investigations we give to the scientific world for what they may be worth.

We wish to present in an entirely conservative manner what may be reasonably expected from the application of the X-ray plus excited fluorescence in the treatment of malignant disease.

In our investigations we found many substances which possessed pronounced fluorescing quality, but most of them also possessed disadvantages which could not be tolerated from a physiological standpoint. We finally decided upon strontium salicylate as being the most widely applicable and at the same time least objectionable chemical. It has abundant fluorescing power and is extremely active chemically, producing a minimum amount of local irritation, and altogether possessing comparatively few physiological disadvantages.

Strontium salicylate when chemically pure occurs in the form of fine white crystals, which are very soluble in water. The salt or a solution of the salt was found one of the most active fluorescing chemicals which we have examined. Although not very much used or mentioned in textbooks as a therapeutic agent, this substance has very valuable properties, chief of which may be mentioned its sedative and anti-pruritic effects when used as a dressing on inflamed or ulcerated wounds. In addition it has a decided tonic action upon the whole system, but more especially upon the blood. It is also antiseptic and antipyretic. After the crystals or a solution of the same have been placed in contact with diseased tissue, the X-ray simply excites the chemical to action, and all the interchange of chemical properties which result from this excitation is appropriated by the cells composing the tissue. It is as efficient internally as externally. It can be applied to the most delicate tissues, as it is perfectly harmless and non-irritating. This substance is particularly rich in ultra-violet rays, and no doubt much of its therapeutic value is due to the fact that we can generate these rays within the tissues, thus getting intimately at the seat of disease. The salt fluoresces irrespective of the vacuum of the tube used, that is, a low, medium, or high tube will excite it. However, since the X-rays, like all remedies which are potent for good, also possess dangerous properties, we suggest that the technique cannot be too exact or too scientific. Our rule is to use a vacuum just high enough to penetrate the diseased tissue, but no more.

Of the two methods by which strontium salicylate can be introduced into the system and then made fluorescent by X-rays, its use by local external application of the crystals is the simplest and safest method. The subcutaneous method, on the other hand, is undoubtedly the most effective method, but not so simple or safe. Various factors decide our choice between external application and hypodermic injection. The latter is to be employed in serious cases, and where it is necessary to act quickly and energetically, and in all cases where the disease is beneath the surface and in internal affections. For the treatment of external or ulcerated conditions it is not necessary to inject the salt in solution. The fine crystals of the same may be freely dusted into the ulcer. When used hypodermically, a saturated solution of stronium salicylate in normal salt solution is prepared. The latter solution, which is also fluorescent under the X-ray, will take up about 26 grains of the chemical per ounce without precipitation. This fluid is heated to a temperature of 100 deg. Fahr. just before using. We prefer to inject all around a growth if possible. The needle is introduced at the edge of the tumor, 5 to 10 drops of the fluid injected, then withdrawn, another place selected, and again 5 to 10 drops deposited, and so on until the growth has been well encircled. In ordinary cases the injections are repeated every other day, while in cases demanding heroic treatment the injections may be resorted to daily, but always just before exposure to the X-ray. Clinical observation teaches that the dose is not of great importance. However, because the substance is practically non-poisonous, we suggest using as large a quantity at one time as can properly be applied. Personally, we have given 60-grain doses frequently without untoward effect. There have been but few cases in which we found any disturbance whatever, and since overstimulation is the only thing to guard against, the quantity which may be used in a given case depends upon the area of tissue to be treated. Patients do not suffer any inconvenience from the treatment. There is no pain except that due to the introduction of the needle, which is very slight.

Concerning the length of time during which this treatment can be administered, we will say that it can be used indefinitely. We have one patient who has taken it for over six months consecutively without the appearance of any disagreeable symptom or sequelæ.

All cases receive the X-ray treatment daily from the beginning; sittings last 8 to 12 minutes, until dermatitis comes on, when we stop. We have employed this method in over one hundred cases, and although individual conditions have varied considerably and many forms of tissue have been under treatment, we have found few contraindications to its use.

An explanation of the possible action which takes place in the tissues under this treatment can only be theoretical. Therefore, we do not care to go into detail concerning this phase of the subject. In all probability its action is largely analogous to that of X-rays. The fluorescence in the tissues probably has a treble action. First, due to the fact that the rays given off are ultra-violet they are bactericidal, or at least have the power of inhibiting bacterial growth; second, the irritating influence is such that nutrition is excited and stimulated; and third, granulations are excited, and thereby rapid healing ensues. There is of course also the probability of the production of new chemical compounds in the tissues as fluorescence is developed. And we may even say that active chemical decomposition takes place, and the effects of the nascent chemicals are made use of by the tissues in which they are liberated.

Of considerable importance is the fact that this chemical exerts not only a local action, but also a general stimulating and tonic action. In many cases it is of great advantage if we can use a remedy which will effect the general as well as the local conditions of the patient.

We must never forget that success of any treatment for a malignant condition does not necessarily depend upon the treatment *per se*, but to a very great extent upon the physical condition of the patient, and also upon the particular part of the body affected by the disease.

To aid us in augmenting the recuperative powers of the system, we have in this chemical also its physiological effects to fall back on. It is a decided stimulator of nutritive processes. It facilitates cellular change, removing diseased cells and causing the elaboration and replacement of healthy ones. We believe it has decided eliminative properties, and for that reason it is of great value in aiding the system to throw off broken-down material, the absorption of which is always a dangerous element during X-ray treatment. In addition, its sedative and anodyne effects are pronounced.

This combination treatment we have used for about two years. During the first year we made no special claims for its superiority as a therapeutic measure, although it was believed, from the start, to possess decided value as such. Now, with rapidly accumulating clinical evidence we feel justified in claiming that it is a most efficient therapeutic measure.

Its field of application is very large; indeed, the number of diseases which may be placed under this combined treatment and benefit derived is so large as to forbid even a casual notice of them all. Suffice it to say that it may be used in almost every condition in which X-rays alone have been found useful.

We shall not burden you with the reading of particular histories of cases treated. Instead we present a summary of all the malignant cases which we have personally treated by this method, classifying the conditions under headings which will be most readily understood. In the majority of the cases herein mentioned, pathological examinations of the growths were made by competent individuals previous to our application of this treatment. The diagnoses therefore were made with all the aids of modern medical science.

Lupus cases treated, 35; primary, 20; secondary (recurrent), 15. Results: symptomatic cures in 28; died from intercurrent disease while under treatment, 2; stopped treatment before discharged, 5. Average length of time under treatment, two months. The term "symptomatic" cures is used to denote cures which have not yet passed the three-year surgical limit. Of the above cases, the disease was located on the trunk in 8, on the head in 15, and on the extremities in 12.

Epithelioma cases treated, 27; primary, 18; secondary, 9. Results: symptomatic cures in 18; died from intercurrent disease having no apparent connection with the epithelioma, 1; died from general infection, 3; stopped treatment before being discharged, 5. Average length of time under treatment, two months. The disease was located on the trunk in 3, uterus 2, head 12, and extremities, 10.

Carcinoma of breast: cases treated, 12; primary, 3; secondary, 9. Average length of time under treatment: primary cases one month, secondary cases three months. Results: symptomatic cures in all primary cases and in five of the secondary cases; died from general carcinosis while under treatment, 1; stopped treatment before discharged, 3.

Carcinoma of the rectum: cases under treatment, 3; primary, 1; secondary, 2. Average length of time under treatment, five months. Results: symptomatic cures in 1 secondary case and none in the primary case; died from general carcinosis, 1.

Carcinoma of the uterus: cases under treatment, 8; primary, 2; secondary, 6. Average length of time under treatment, four months. Results: symptomatic cures in 1 primary case and in 3 secondary cases; died from general infection, 2; died from concomitant disease, 1; stopped treatment for some other treatment, 1.

Tubercular gland cases under treatment, 14; primary, 10; secondary, 4. Average length of time under treatment, three months. Results: symptomatic cures in 7 primary cases and in 3 secondary cases; died while under treatment, 1; stopped treatment for some cause or other, 3.

Sarcoma cases treated, 2; 1 primary; 1 secondary. Results: the secondary case stopped treatment after three weeks, due to financial difficulty. During the time he was under treatment, there was a marked change in the growth as well as in his general condition. The primary case progressed very favorably indeed for two months, and we were very hopeful of a symptomatic cure, when the patient met with an accident from the effects of which she died a few hours later.

It is of special interest to note that in some of the secondary cases mentioned in the above list the usual methods of treatment yielded but negative results, and we received the patients for treatment therefor without much hope for improvement; however, it was surprising how many of these so-called "hopeless" cases were symptomatically cured.

Lest we be misunderstood, we will say that when feasible, surgical measures should not be neglected in all malignant conditions. The X-ray treatment is indicated primarily when surgical measures are not applicable, or when the diseased condition is inaccessible to the knife, and also as post-operative treatment.

In treating breast cases particularly we always expose the glandular region on the affected side for the purpose of stimulating glandular activity. In treating tubercular glands the chemical should be injected, not into the glands, but around them.

The results obtained by this method of treatment are certainly very satisfactory, for out of 101 cases we have been able to report 69 symptomatic cures. Most of those pronounced cured have been under observation for a period of from one-half to two years; in only a few cases could the results be called unsuccessful.

We do not present this method as infallible, but if the X-ray is indicated in a given case, then we say the combination treatment will bring about results far superior to X-ray treatment alone.

We feel justified by reason of the many favorable results in saying that with this combination treatment nearly all malignant conditions can be arrested in their growth, and in properly selected cases the majority can be cured. What we have said of this treatment is based upon clinical experience, and we feel safe in saying that it will bear a clinical test

whenever properly administered. More clinical experience will no doubt add something to or change somewhat the present method of employing this remedy, but even as it now stands, it offers the profession probably the only approach to result-producing treatment in some of the most distressing and fatal diseases to which human flesh is heir.

GERMAN-SILVER KNIFE TIPS.

EVERYONE is familiar with the ordinary pocket-knife and has seen the tips on them made of German silver. It may be a surprise to many to know that many of these tips are made of German-silver castings, says the Brass World. This line of trade probably constitutes the smallest size casting that enters the brass foundry. As far as known, there is now only one foundry in the United States that produces the tips.

The advantage of the cast German-silver tip over one made from sheet German silver, is that it is ready for use and requires no blanking or stamping to form it. In the use of sheet German silver, the tips must first be blanked out. This necessitates the production of forty or fifty per cent of scrap. After the tips have been blanked they must be formed under a drop, with successive annealings, until they are formed into the oval shape, ready for use. The cast German silver, however, only requires polishing and is ready for use.

The tips are cast with a large number on a gate and with two gates in a flask. They are poured "on end." Scrap German silver is used and about two ounces of aluminium are added to 100 pounds of metal. The aluminium reduces the oxide in the German silver and it then runs very freely. The color is also much improved and soundness is imparted to it.

The manufacture of these German-silver knife-tips forms a unique industry. They are so small that one would scarcely believe that it pays to make them in this manner. In the smallest sizes, several hundred pieces make a pound. The price obtained for them is from 50 cents to $1.00 a pound. The foundry which is making them claims that it pays.

COMETS.

THE nuclei of comets are in general collections or aggregations of meteorites, which are easily broken up into smaller groups or gradually spread and dispersed along a comet's path until it may at last happen that the comet will be wholly dissipated and be seen no more. In any case dynamical considerations indicate that the meteorites must continue to travel very nearly in the comet's orbit.

This hypothesis is confirmed by cases in which the nucleus in the head of a comet has actually appeared to undergo division. In the comet of 1618 it is recorded that the head was at first like a planetary disk, but presently the astronomer Cysatus saw it as a clustering group of starry points. The comets of Olinda in 1860 and of Brooks in 1889 broke into two parts, somewhat as did Biela's. The nucleus of the great comet of 1882 gradually broke into four portions, each of which it is quite conceivable may some day form a separate comet.

But it may be asked: If comets are thus composed of aggregations of meteorites, of what size may we suppose the meteorites to be? The answer is that their size will probably correspond with that of such meteorites as the earth is constantly encountering. These frequently fall upon it, being sometimes of a few pounds in weight or occasionally attaining even to hundredweights or tons, as is indicated by specimens found *in situ* in certain localities, although they may not actually have been seen to fall. But it is likely that the weight of by far the greater number may attain to only a grain or two, as is the case with most of those which traverse the earth's atmosphere in the form of shooting stars.

A comet's nucleus is therefore probably composed chiefly of stony fragments varying in size from that of the finest dust to that of rocks of considerable magnitude. At the same time portions of a more or less metallic composition may be intermingled.

Eruptions from the nucleus may take place in any direction. But they occur, as might be expected, most frequently toward the sun, because on that side most heat is received. When so erupted the matter sent forth is in general seen to be presently thrown back again in a curved path past the nucleus, so as to form a brilliant hollow envelope around it, the nucleus being within that part of the envelope which is most curved and convex toward the sun. Several such envelopes, outlying each other, are sometimes seen, which have been formed in succession from a series of explosions, the matter projected having attained to different elevations above the nucleus before being turned back.

These envelopes, produced in this way from jets first of all emitted toward the sun, of course help to form the comet's tail after they have passed back beyond the head. A much smaller amount of ejected matter, probably of a different kind, is sometimes seen on the sunward side of the head, like a tail pointing toward the sun, and has occasionally been termed the comet's beard. But the tail proper, frequently of immense extension and always of almost inconceivably light density, invariably points away from the sun; so that it even travels, in a sense, in front of the comet after the perihelion passage has taken place and the comet has begun to recede from the sun again.

All this very clearly indicates, as nearly all astronomers have long allowed, that some great repulsive force emanates from the sun, which drives away with enormous speed in the opposite direction any matter ejected toward the sun from the comet's nucleus after it has risen to a certain elevation; while the same force, if such matter is ejected in any other direction from the nucleus, sooner or later turns it all, in like manner, backward into the tail.—The Nineteenth Century and After.

SCIENCE NOTES.

Two new compounds have been formed by M. Duboin, of Paris. These are the iodo-mercurates of sodium and barium. He employs the dense liquid based upon iodo-mercurates of alkalis. This liquid is evaporated in dry air for several weeks before the crystals begin to form. The new sodium compound appears in the shape of flat crystals which have a density of nearly 3 at 0 deg. C., and a formula $2NaI, HgI_2, 4H_2O$. They are very deliquescent. As to the second compound, the iodo-mercurate of barium, it is formed by letting stand for a long time a solution of mercuric iodide in barium iodide composed as follows: barium 12.45 parts, mercury 22.53, iodine 51.68, water 13.34. The solution deposits very large and flat crystals measuring an inch wide and but 0.04 to 0.08 inch thick. At zero, the density is 4. The formula for this body is found to be $BaI_2, HgI_2, 5H_2O$.

The Hamites are to be regarded as the true indigenous element in North Africa, from Morocco to Somaliland. Two main divisions of this stock are generally recognized: (1) the northern or western Hamites (or Mediterranean race of some authors), of which the purest examples are perhaps to be found among the Berbers; and (2) the eastern Hamites or Ethiopians. These two groups shade into each other, and everywhere a negro admixture has taken place to a variable extent since very early times. The Hamites are characterized by a skin-color that varies considerably, being white in the west, and various shades of coffee-brown, red-brown, or chocolate in the east; the hair is naturally straight or curly, but usually frizzly in the east. The stature is medium or tall, averaging about 1.670 meter (5 feet 5¾ inches) to about 1.708 meter (5 feet 7¼ inch); the head is sub-dolichocephalic (75 to 78); the face is elongated, and the profile not prognathous; the nose prominent, thin, straight, or aquiline, with narrow nostrils; lips thin or slightly tumid, never everted.

A quarter of a century ago Lord Kelvin summarized the stores of energy from which mechanical effects can be drawn by man as follows: (1) The food of animals, (2) natural heat, (3) solid matter found in elevated positions, (4) the natural motions of water and air, (5) natural combustibles, (6) artificial combustibles. The twenty-five years which have since elapsed have not made it possible to extend this list. It is true that within the last few years the discoveries connected with radio-activity have enormously increased our estimate of the stores of energy surrounding us, but so far these additional stores cannot be regarded by us as stores from which "mechanical effects may be drawn by man." It is possible that in the ingenious radium clock which we owe to Mr. Strutt we have a source of mechanical energy unsuspected in 1881, but, at all events, regarded from a commercial standpoint, it can hardly be considered as "available by man." Nevertheless, there is a sense in which it may be said that we are profiting by atomic energy, for we are no longer bound to limit our estimate of the energy due to the radiant heat of the sun and the internal heat of the earth by previously known dynamical considerations, and, in consequence, our opinions with regard to the limit of the ages which the physicist could allot to the evolutionist have undergone profound modification.

The combinations of silicon with titanium and zirconium have not been well observed up to the present. Two new, or at least imperfectly-known bodies are produced by Otto Hönigschmid, of Paris. These are the silicides of zirconium and titanium. The former body is formed by heating in a Perrot gas furnace 120 parts of potassium fluosilicate, 15 parts double fluoride of zirconium and potassium and 50 of metallic aluminium. The product of the reaction appears in the form of brilliant metallic crystals, which are then freed from the ingot of aluminium by treating with acids. The silicide of zirconium here formed still contains a small amount of aluminium. To avoid this the experimenter uses the alumino-thermic method. In a Hessian crucible he places 200 parts of powdered aluminium, 250 of sulphur, 180 of fine sand, and 15 parts titanic acid. This is covered with a layer of magnesium powder, and the whole is lighted by a Goldschmidt cartridge. The product of the fusion is a mixture of crystals of silicon and of the new silicide. Examining this latter body he finds it to be formed of small iron-gray crystals having a brilliant metallic luster. These crystals are small rhombic columns which have the hardness of feldspar, and their density is 4.88. Air does not change them. In fine powder, heated on platinum foil, they burn with a brilliant flame, and the product of combustion when attacked by hydrofluoric acid leaves a brown residue of silicon. The new compound burns well in oxygen, and also in fluorine and chlorine gas. Mineral acids have no action on it, with the exception of hydrofluoric acid, which dissolves it easily. Potash in fusion decomposes it. The formula for this body is $ZrSi_2$. Another new compound, the silicide of titanium, is formed in the same way, and it appears in small tetragon pyramid crystals of a gray color, and a density of 4.02. It burns less easily in oxygen than the above body, but will burn in chlorine below a red heat. Its formula is $TiSi_2$.

ENGINEERING NOTES.

The fire in Anchor colliery of the Reading Company, which started thirty-seven years ago, is still burning as fiercely as ever. When the fire got beyond control of the fire fighters the mine was closed and filled with water. It has been filled since that time. Recently it was decided to pump out the water in the hope that the fire had been extinguished, but to-day when much of the water had been taken out it was found that it was still burning.

The past year has been noteworthy as a record breaker in the continuation of the prosperous conditions which have prevailed during the past decade. Exceptionally favorable weather conditions, combined with large additions to equipment, enabled the railroads to meet the emergency in a creditable manner. Locomotive and car plants have been taxed to their utmost capacity to meet the requirements of the railroads, whose orders in many cases were the largest placed in railroad history. Statistics compiled for the year 1905 show a large increase in output of new locomotives, over the year 1904, as the following data will indicate:

	1905.	1904.	Inc.
Total number of locomotives built for domestic use and for export, by locomotive builders	5,491	3,441	60 p. c.
Total number of locomotives built for domestic use by the builders, and in railroad shops	5,176	3,198	61 p. c.
Compound locomotives built for domestic use	177	132	34 p. c.
Balanced compound locomotives built for domestic use.	76	41	85 p. c.
Number of electric locomotives built	140	95	47 p. c.

British railroad engineers are interested in a new automatic apparatus that has been devised for the dropping and picking up of freight at stations by railroad trains without stopping. In this system the handling of the goods within the coach, or car, both for embarking and discharging, is entirely automatic in its action. In the case of goods for delivery these are packed in a special outer case in the fore part of the coach, through the length of which extends a grooved track along which the package travels, being set in motion, as the train approaches the point of discharge, automatically. Connected to the operating mechanism and protruding through the roof of the vehicle is a small trigger. Near the point at which the freight is to be discharged are placed upright pillars beside the track with a cross beam. As the train passes beneath this apparatus the trigger in the roof is released, the mechanism set in motion, and immediately the package containing the freight travels toward the rear of the compartment at the same speed at which the train is traveling. This arrangement of pressure of speed against speed sets up a neutralizing effect, so that when the point of discharge is reached the package falls through the outlet at the end of the coach specially provided for the purpose, by its own gravity, and concussion with the ground is imperceptible. For the purpose of picking up freight, the latter is swung on supports and as the train passes is grabbed by a hook and swung into the van and carried by the mechanism toward the fore part of the vehicle without the slightest shock or vibration. If necessary exchanges can be effected simultaneously. The system is specially applicable to the transport of newspaper packages and consignments of other soft goods which cannot be damaged in falling to the ground.

According to the Iron Age there exists a widespread misapprehension of the immediate future of the alcohol engine as it affects the combustion engine business. The belief that almost immediately the market will be supplied with perfected engines using alcohol for fuel and that it will be a very simple matter to convert a gasoline or kerosene engine for the new fuel, appears to exist pretty much everywhere among users and prospective users of combustion engines, and frequent instances are reported of customers deferring purchases of motors pending the removal of the tax on alcohol. It is true that many designers are at work on the new problem and that manufacturers are turning their attention to the new field; that engines will soon be available, in most instances based on German designs, that country having taken the initiative in adapting alcohol for fuel, and that the designers are working under the immense advantage of having back of them the almost innumerable problems of the combustion engine which have been solved for gasoline and kerosene. Nevertheless, it is quite probable that considerable time will be spent before the alcohol engine is developed to the standard of the gasoline and kerosene engines of to-day. Each fuel presents its individual peculiarities, more or less akin, to be sure, but sufficiently distinctive to require extended experiment and exhaustive tests in practical use before imperfections in design can be wholly eliminated. Even to-day both gasoline and kerosene engines have their weaknesses, more or less peculiar to each. So will the designers and manufacturers of alcohol engines have their troubles, which only experience can remove or minimize. The seekers after a cheaper and cleaner fuel should bear in mind that the advantages they are seeking will very likely have their drawbacks for a time. Doubtless some excellent alcohol engines are now ready for the market, but what they will accomplish remains to be demonstrated. Some of them may

prove satisfactory, and as likely some of them will have their weaknesses, which will annoy those who buy them. On the other hand, the gasoline and kerosene engines have been tried out in the hard test of practical use. Still it is to be expected that perhaps before another year has passed there will be on the market engines which will burn alcohol with perfect results as compared to other sources of power.

ELECTRICAL NOTES.

The city of Athens is connected with the coast by an electric railroad which has been operating successfully for some time past. To carry this out a steam railroad was electrified, this line belonging to the Athens-Piraeus Company. It starts from the port of Piraeus, makes a turn toward the south so as to take in the town and beach of New Phalere, and reaches Athens, where there are three stations within the city. The terminus of the line is at a large square in the center of the city, and the line runs within the city limits in a tunnel. It was owing to the existence of the underground part and also on account of the greatly-increased passenger traffic between Athens and the beach of Phalere that it was decided to replace the steam system by electric trains, and accordingly the line was transformed for the purpose. The trains are made up of long motor cars and trailers of about the same build, and the traffic requires trains of 200 places running every five minutes or 300-place trains running at 7½-minute intervals. A large electric station has been erected at Phalere for supplying the road and for the electric lighting of Athens and the neighboring localities. This plant, as well as the electric outfit of the traction line, has been supplied by the French Thomson-Houston Company from their Paris shops. In the electric station are four main engine-and-dynamo units. The engines are of the horizontal compound type giving 1,000 horse-power, and two of them are connected direct to alternating current dynamos. The latter machines give three-phase current at 5,500 volts. For the electric railroad two groups of the same power are used. One of these uses a direct current generator and to the other engine are coupled an alternator and a direct-current machine, either of which can be used. The road is operated on the third-rail system.

In view of certain misleading reports which have been circulated on the subject, it may be of interest to our readers to know that the electrification of the lines through the Simplon tunnel is now complete. Since August 1 the Brown-Boveri electric locomotives have drawn fifteen trains daily through the tunnel. The only steam-operated trains are the through trains *de luxe* (which run three times a week), and, in addition to these, one other engine passes daily through the tunnel from the locomotive sheds at Brigue for service between Iselle and Domo Dossola. As was only to be expected, some technical difficulties were met with at first. Considerable deposits of soot had accumulated on the insulators of the overhead conductors, and these had to be very thoroughly cleaned during the intervals between working. Further, owing to the unusually damp condition of the atmosphere in which the motors have to work, it has been found advisable to completely inclose them and to depend entirely on internal ventilation, no air whatever being allowed to enter from the outside. The electric locomotives have now been running regularly since August 1, and the whole system is working most satisfactorily. In addition to the 1,000-horse-power locomotives already supplied, Messrs. Brown, Boveri & Co. have two similar locomotives in hand for the further requirements of this service.

A New Harmonic Synthetizer.—A paper by J. R. Milne in the Proceedings of the Royal Society of Edinburg describes a new form of instrument for mechanically drawing curves which are the summation of a number of simple harmonic curves. The general principle of the instrument is the use of a long continuous wire attached at one point to a parallel motion carrying a pen bearing against a drum with a vertical axis, and passing alternately over small fixed and movable pulleys. The moving pulleys are carried eccentrically on a series of revolving wheels, each representing a constituent harmonic. Thus the resultant motion of the wire, and therefore of the pen, is a very near approximation to a summation of the various harmonic motions which are the projections of the circular motions of the moving pulleys, provided that the distance apart of the fixed and moving groups of pulleys is large compared with the amplitude of the displacement. An arrangement of coned pullies permits of a variation of the period of a constituent harmonic by alteration of the speed ratios of the wheels. A further device is provided for varying the amplitude of a constituent harmonic. This consists of two co-axial bevel wheels geared together after the manner of a differential gear by a third bevel wheel on a radial axis, whose angular position is capable of adjustment. These two wheels, therefore, revolve at the same speed in opposite directions, and both carry eccentric pulleys round which the summation wire passes. It is thus possible, by varying the position of the connecting bevel wheel, to alter the phase relation of the two components and set them so that their maxima either coincide and assist each other or oppose and neutralize each other, or in the intermediate positions the resultant motion may possess any amplitude between these limits. A small electromotor drives the wheels by a leather belt through a worm reduction gear. The accuracy of the records is discussed mathematically in the paper, and in the particular apparatus considered the error is shown not to exceed 1/160 inch.

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